Middle Eel River

Watershed Management Plan

SECTION 3

WATER MONITORING

1/6/11

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3.0 Water Monitoring

3.1 Water Monitoring Locations

For this watershed study, there were nine primary sites for water monitoring; three on the mainstem, and six tributaries of the Middle Eel River.

The Quality Assurance Project Plan that was approved by IDEM outlines the monitoring program for the Initiative (Appendix D).

Three automatic water samplers with data loggers and stream discharge gages were installed on the mainstem: the most upstream site near North Manchester as the water enters the watershed (Blocher Gage), one at the watershed break between the two 10 digit HUCs near Chili (Paw Paw Gage), and one at the most downstream site of the watershed near Mexico as the water exits the watershed (Mexico Gage) (Figure 3-1). The upstream site is located just downstream from the town of North Manchester at river mile 49 or 85^{o} 48’ 34.5” and 40^{o} 59’ 45.1”. The middle site is just downstream from the confluence of Pawpaw Creek at river mile 32.4 or 85^{o} 58’ 38.7” and 40^{o} 52’ 23.9”. The most downstream site is near the town of Mexico, Indiana near old U.S. 31 or river mile 18.26 or 80^{o} 06’ 42.1” and 40^{o} 48’ 49.4”. These sites were strategically chosen in order to more precisely determine the contribution of nonpoint source pollution (NPS) from each 10 digit HUC and to determine the water quality coming into and leaving the watershed. Gage stations water monitoring consisted of six automatic daily samples, with four of the six analyzed daily at base flow, and all six analyzed daily following rain events.

The six tributaries were selected as sampling sites because of their large watershed areas and major contribution to the mainstem. These six tributaries include: Beargrass Creek, Pawpaw Creek, Squirrel Creek, Weesau Creek, Silver Creek, and Flower’s Creek. Testing tributary water monitoring consisted of weekly grab samples during base flow and daily grab samples following rain events. Figure 3-1. shows all of the testing locations.

The sampling approach for this project was a targeted design that focused on the assessment and quantification of the chemical, physical, and biological attributes of the stream reach. Due to the lack of consistent, rigorous water quality monitoring of the Middle Eel River, baseline data was established using only the first year of data collected at sampling locations.

All water monitoring data is available by request.

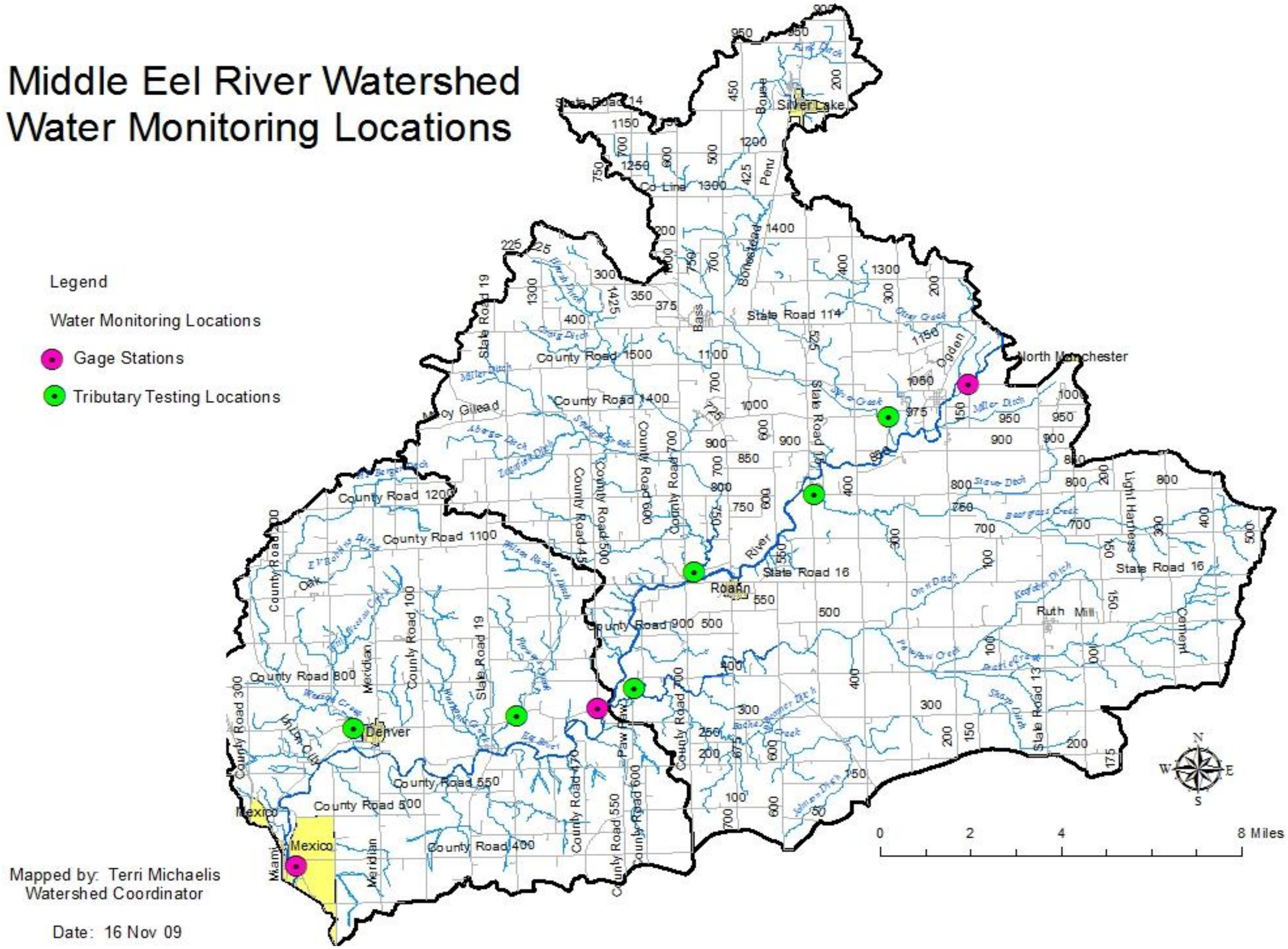

Figure 3-1. Middle Eel River Watershed Monitoring Locations.

3.2 Historical Water Monitoring

Long term studies in north central Indiana have been focused primarily on the Wabash and Tippecanoe Rivers, consequently there is not a great deal of historical data available for the Middle Eel River.

Historical water quality monitoring data for the Middle Eel River Watershed was obtained through the United States Environmental Protection Agency STORET Legacy Data center. Parameters gathered included that of temperature (Degrees Celcius), Nitrogen (Kjeldahl mg/L), Ammonia (mg/L), Escherichia coli (CFU's per 100mL), pH, Total Supended Solids (mg/L), Turbidity (NTU), Specific Conductance (uS cm), and Dissolved Oxygen (mg/L) (U.S. Enivronmental Protection Agency, 2007). The record number is RECORD~0~40.94~-85.89~NAD83, which indicates the location of the monitoring and is shown on Figure 3-2.

STORET data files contained abundant information, but held incomplete data regarding Nitrogen, Ammonia, and Escherichia coli. Data was typically present from the year of 1991 to 2005, with the exception of 1992. The data for 1992 includes only 6 temperature and pH readings and only 5 TSS results. The reason for a lack of data in 1992 is unknown. Most parameters typically contained enough data to calculate an annual mean. Data that did present enough information to calculate an annual mean were compared using a bar graph to indicate any large fluctuation in data. Parameters that did not contain enough information were analyzed using a bar graph to compare data values over a range of years, typically 3-4 years. Figures 3-3 through 3- 9 show annual mean results and bar graphs for the STORET data.

The historical data is from grab samples collected from 1991 – 2005 in only one location. Because these are grab samples, from only one location, it is not possible to compare them to the current water monitoring results. The historical data is included in this report for information purposes.

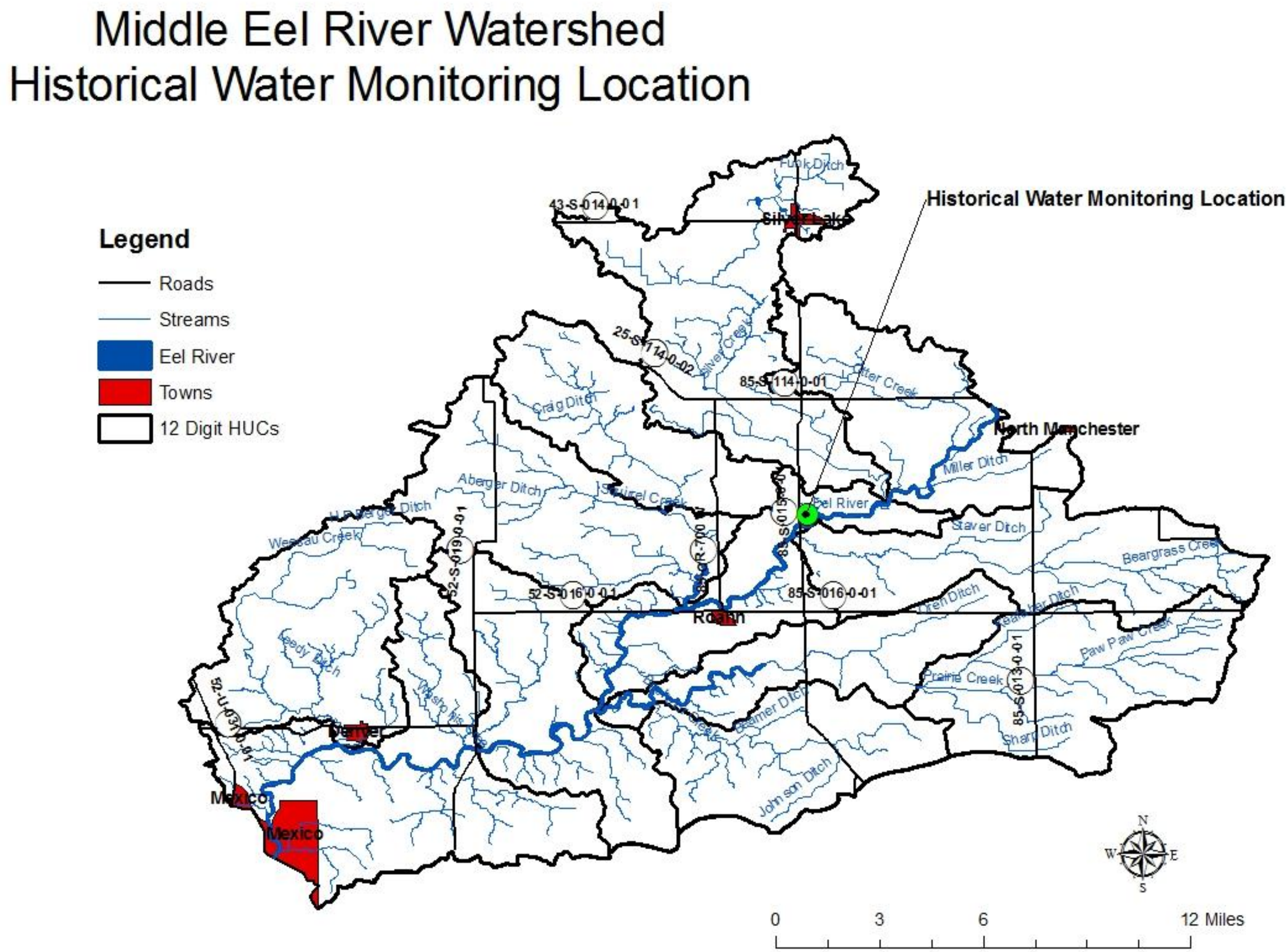

Figure 3-2. Historcial Water Monitoring Location, Latitude 40.94, Longitude -85.95 for STORET data.

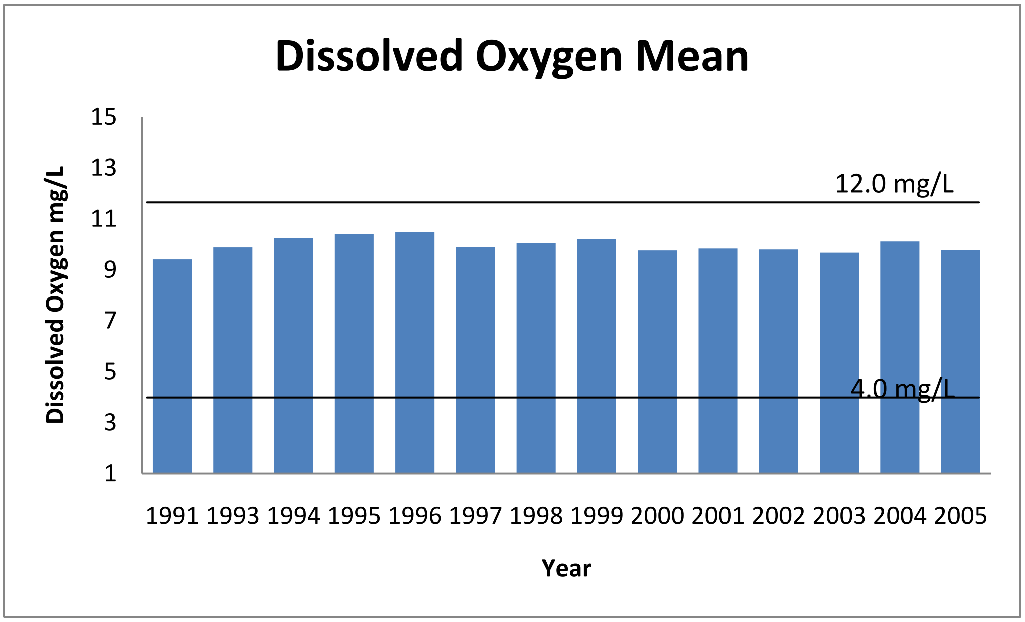

Figure 3-3. Historical water monitoring data, annual mean of dissolved oxygen in mg/L from 1991-2005, information gathered from STORET Database, RECORD~0~40.94~-85.89~NAD83 (http://iaspub.epa.gov/tmdl_waters10/attains_get_services.storet_huc?p_huc=05120104). IDEM target for Dissolved Oxygen is a minimum of 4.0 mg/L and maximum of 12.0 mg/L.

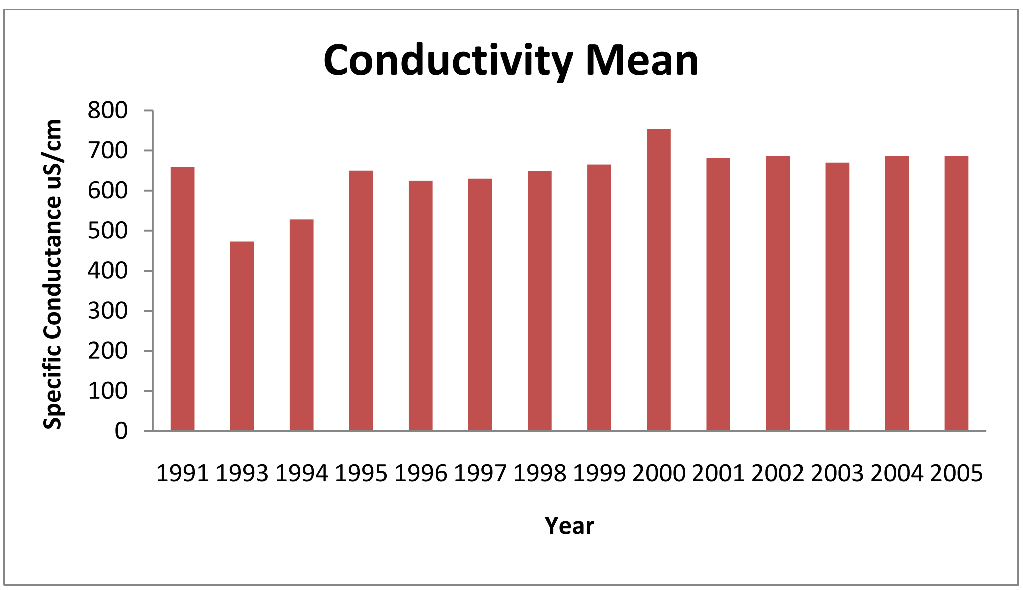

Figure 3-4. Historical water monitoring data, annual mean of specific conductivity in uS/cm from 1991-2005, information gathered from STORET Database, RECORD~0~40.94~-85.89~NAD83. There is no designated target for conductivity since it varies from stream to stream. (http://iaspub.epa.gov/tmdl_waters10/attains_get_services.storet_huc?p_huc=05120104).

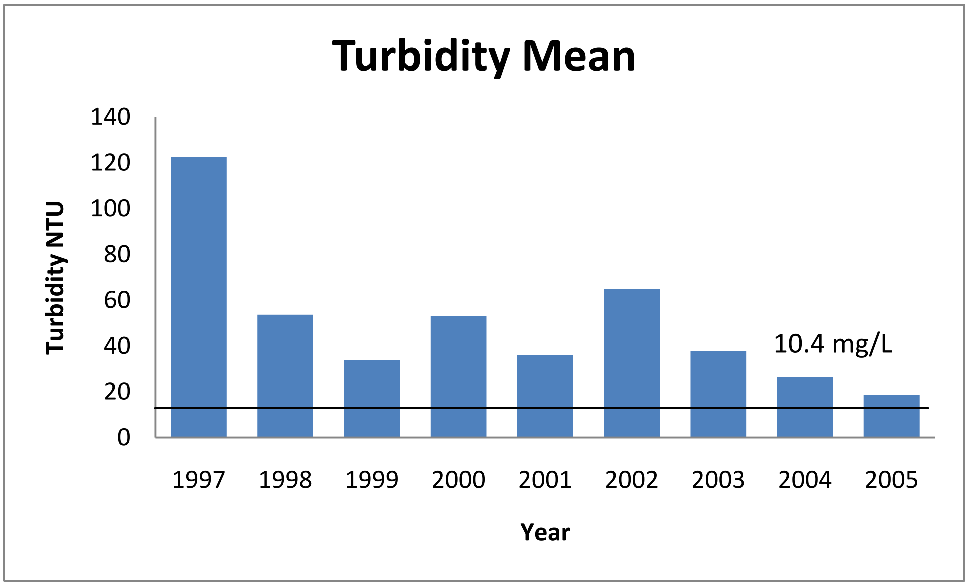

Figure 3-5. Historical water monitoring data, annual mean turbidity in NTU from 1997-2005, information gathered from STORET Database, RECORD~0~40.94~-85.89~NAD83. (http://iaspub.epa.gov/tmdl_waters10/attains_get_services.storet_huc?p_huc=05120104). USEPA recommendation for Turbidity maximum of 10.4 NTU.

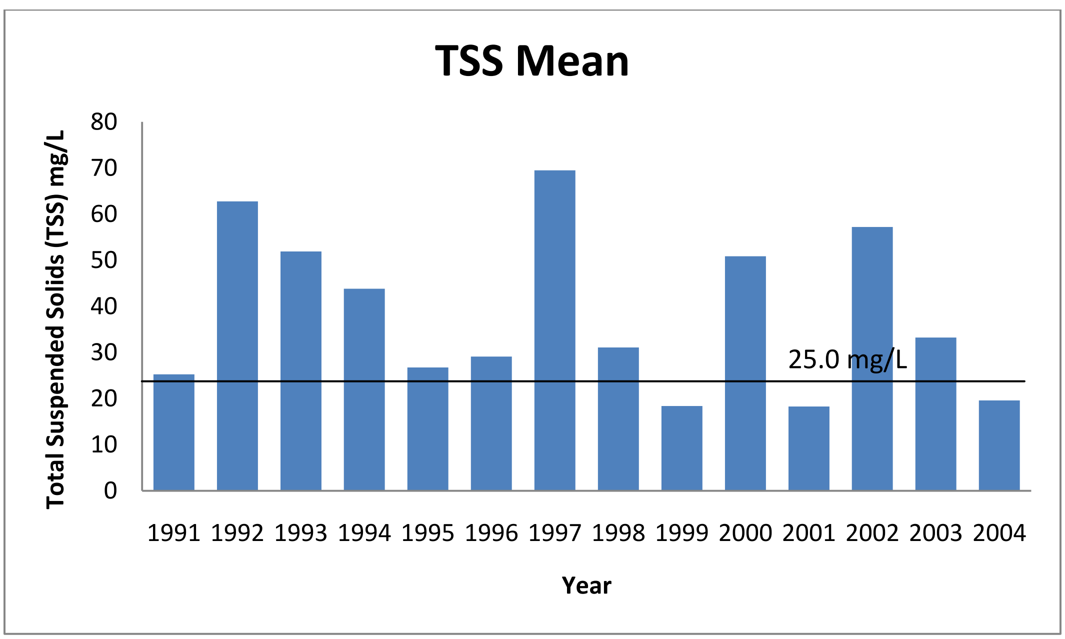

Figure 3-6. Historical water monitoring data, annual mean of Total Suspended Solids (TSS) in mg/L from 1991-2004, information gathered from STORET Database, RECORD~0~40.94~-85.89~NAD83. (http://iaspub.epa.gov/tmdl_waters10/attains_get_services.storet_huc?p_huc=05120104). IDEM draft TMDL for TSS maximum of 30.0 mg/L.

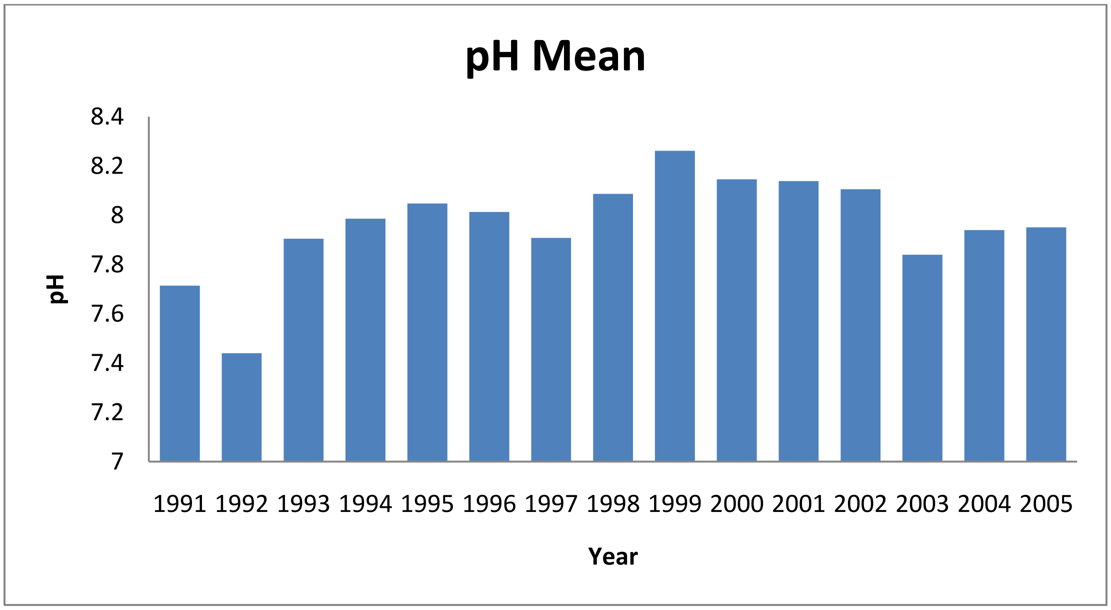

Figure 3-7. Historical water monitoring data, annual mean of pH from 1991-2005, information gathered from STORET Database, RECORD~0~40.94~-85.89~NAD83. (http://iaspub.epa.gov/tmdl_waters10/attains_get_services.storet_huc?p_huc=05120104).

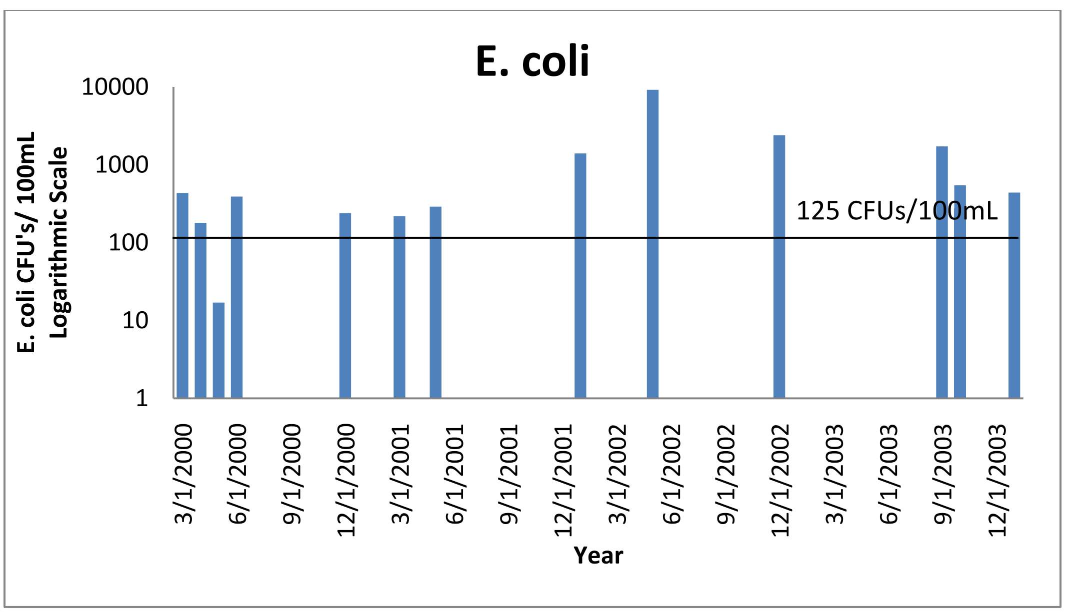

Figure 3-8. Historical water monitoring data, *E. coli* in CFUs/100 ml, using a logarithmic scale, information gathered from STORET Database, RECORD~0~40.94~-85.89~NAD83. (http://iaspub.epa.gov/tmdl_waters10/attains_get_services.storet_huc?p_huc=05120104). IDEM target for E. coli maximum of 235 CFU/100mL in a single sample.

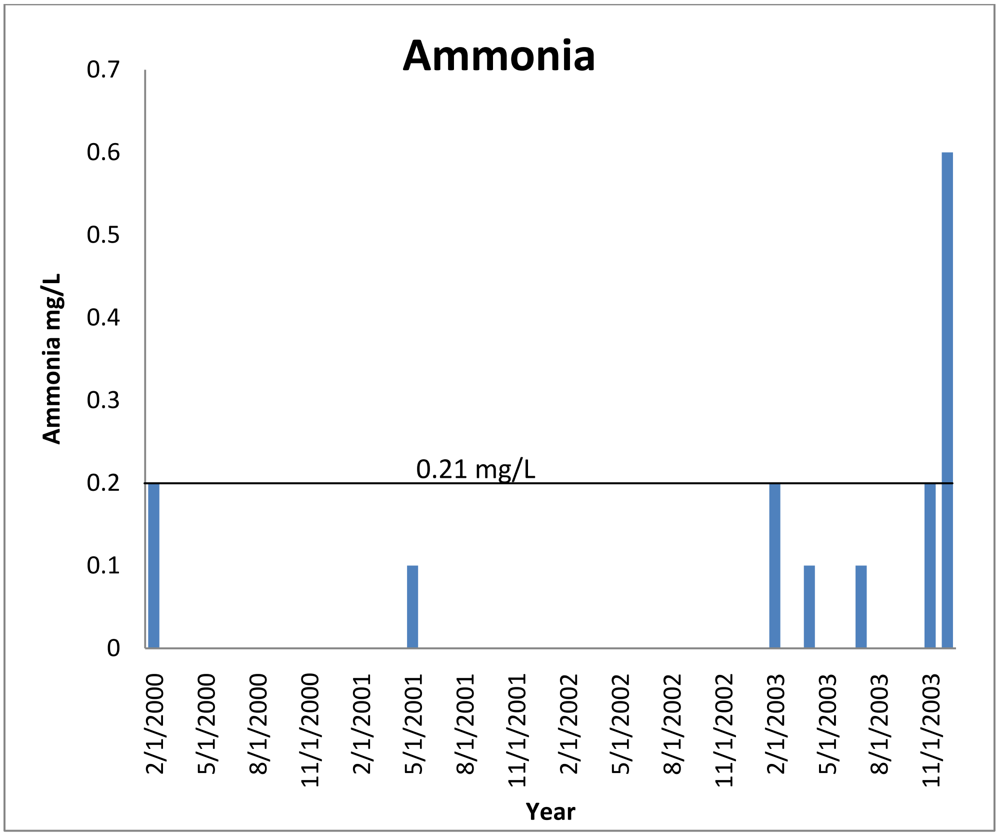

Figure 3-9. Historical water monitoring data, ammonia in mg/L, information gathered from STORET Database, RECORD~0~40.94~-85.89~NAD83. (http://iaspub.epa.gov/tmdl_waters10/attains_get_services.storet_huc?p_huc=05120104). IDEM target for ammonia 0.0-0.21 mg/L depending on temperature and pH.

More recent water monitoring data was made available through IDEM at this same location that included monthly grab samples from April 2007 – Feb 2010. The results for total phosphorus and TSS are shown in Figure 3-10 and 3-11 below. This data is from monthly grab sampling and cannot be compared to the current water monitoring results and is provided for information purposes.

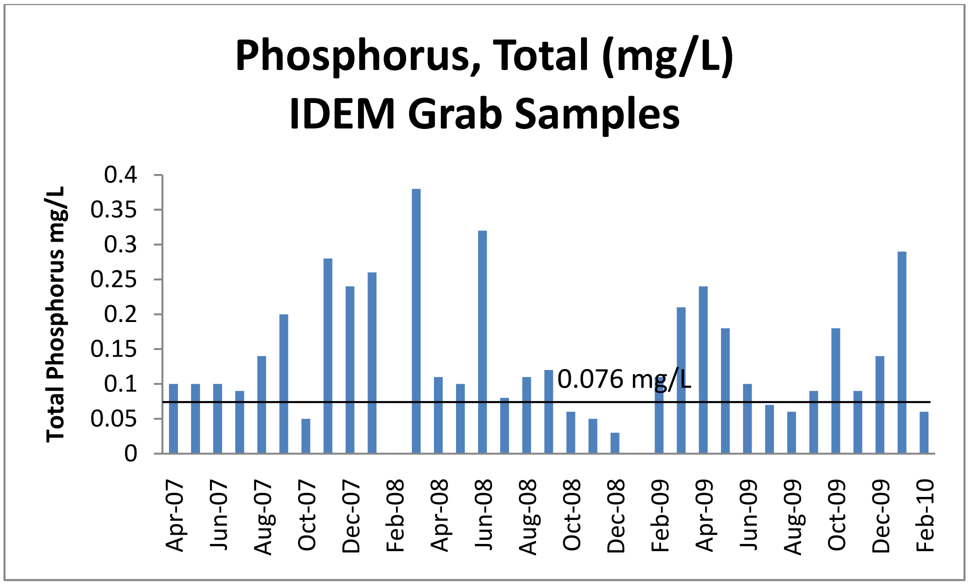

Figure 3-10. IDEM monthly grab samples, total phosphorus in mg/L, data from Angie Brown, IDEM Watershed Specialist. IDEM target for total phosphorus maximum 0.076 mg/L.

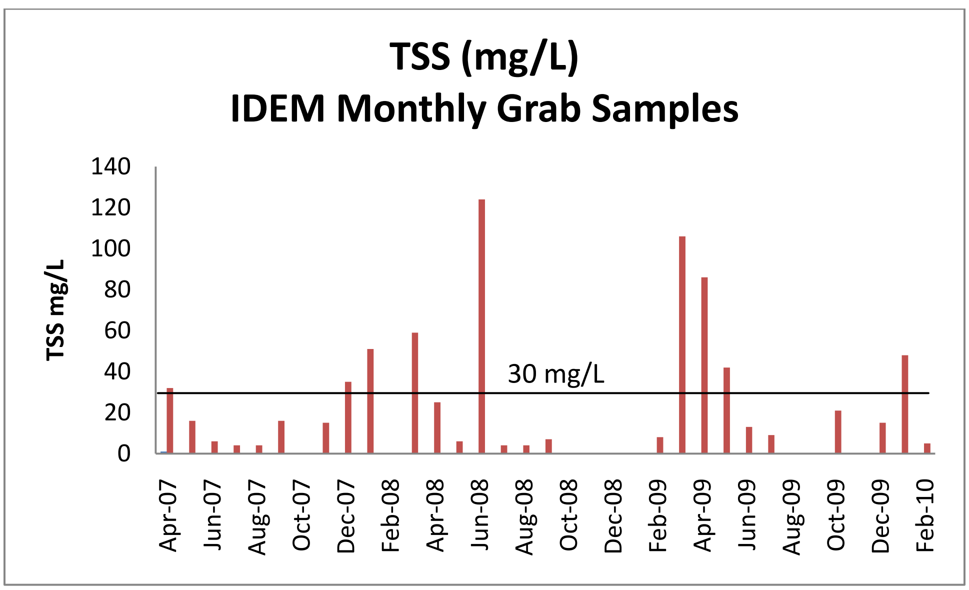

Figure 3-11. IDEM monthly grab samples, TSS in mg/L, data from Angie Brown, IDEM Watershed Specialist. IDEM target for TSS maximum 30 mg/L.

3.3 IDEM 303(d) List of Impaired Waters

IDEM is required to perform water monitoring as part of the Clean Water Act Section 303(d) to identify waters that do not meet the state's water quality standards for designated uses. IDEM has divided the state into five major water basins and the water quality monitoring strategy calls for rotating through each of the five basins once every five years. The Middle Eel River Watershed was included in the 2008 rotation. According to IDEM's Surface Water Quality Monitoring Strategy, the following data is collected within each 12 digit Hydrologic Unit Code to determine if the state water quality standards are being met:

- Physical or chemical water monitoring
- Fish Community Assessment
- *E. coli* monitoring
- Benthic aquatic macroinvertebrate community assessment
- Fish Tissue and superficial aquatic sediment contaminants monitoring
- Habitat evaluation

Water quality standards for the state of Indiana are designed to ensure that all waters of the state, unless specifically exempt, are safe for full body contact recreation and are protective of aquatic life, wildlife and human health. The Middle Eel River and its tributaries are required to be fishable, swimmable, and able to support warm water aquatic life. The Middle Eel River and many of its tributaries were listed on the 1998, 2002, 2004, 2006 and 2008 IDEM 303(d) Impaired Waters List. Each waterbody listed on the 303(d) list is placed into one or more of five (5) categories depending on the degree to which it supports its designated uses as determined by IDEM's assessment process. The following is a summary of the five (5) categories:

Category 1 **All designated uses are supported and no use is threatened**.

Category 2 **Available data and/or information indicate that some, but not all of the designated uses are supported.**

Category 3 **There is insufficient available data and/or information to make a use support determination.**

Category 4 **Available data and/or information indicate that at least one designated use is impaired or is threatened, but a TMDL is not needed.**

A. A TMDL has been completed that is expected to result in attainment of all applicable WQS and has been approved by U.S. EPA.

B. Other pollution control requirements are reasonably expected to result in the attainment of the WQS in a reasonable period of time

C. Impairment is not caused by a pollutant.

Category 5 Available data and/or information indicate that at least one designated use is not supported impaired or is threatened, and a TMDL is needed.

A. The waterbody AU is impaired or threatened for one or more designated uses by a pollutant(s) and require a TMDL.

B. The waterbody AU is impaired due to the presence of mercury and/or PCBs in the edible tissue of fish collected from them at levels exceeding Indiana's human health criteria for these contaminants.

All of the listed impaired water bodies within the Middle Eel River Watershed are Catergory 5, A or B. There are currently no TMDLs for the Middle Eel River Watershed. The locations and specific impairments listed in the Indiana 2008 303(d) list within the Middle Eel River Watershed are listed in Table 3-1 and shown on Figure 3-12.

Table 3-1. Middle Eel River Watershed Impairments by 12 Digit Hydrologic Unit Code (IDEM 2008 303(d) List).

12 Digit HUC	**HUC Name**	**Impairment**	**Category**
051201040502	Otter Creek	*E. coli*, PCBs in Fish Tissue	5A & B
051201040501	Silver Creek	Phosphorus, *E. coli*, PCBs in Fish Tissue	5A & B
051201040503	Beargrass Creek	*E. coli*	5A
051201040505	Squirrel Creek	*E. coli*	5A
051201040509	Town of Roann – Eel River	*E. coli*	5A
051201040509	Town of Roann – Eel River	PCBs in Fish Tissue	5B
051201040508	Oren Ditch-PawPaw Creek	*E. coli*	5A
051201040601	Flowers Creek-Eel River	Dissolved Oxygen, Impaired Biotic Community, Nutrients, Mercury and PCBs in Fish Tissue	5A & B
051201040603	Washonis Creek-Eel River	*E. coli,* Mercury and PCBs in Fish Tissues	5A & B

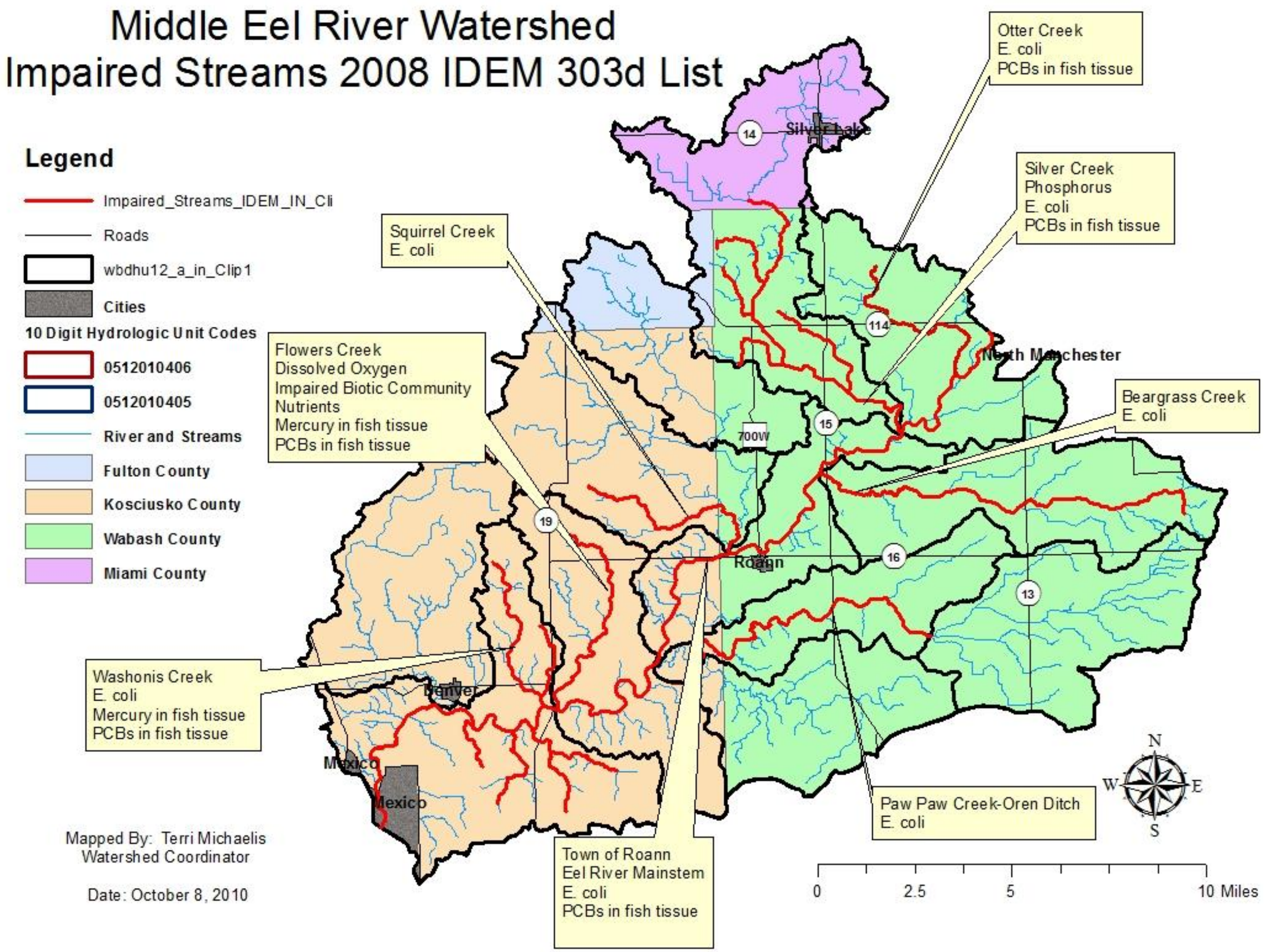

Figure 3-12. Middle Eel River Watershed, 2008 Impaired Streams, IDEM 303(d) List.

3.4 Mussels

Freshwater mussels are some of the most imperiled organisms in North America as shown in Figure 3-13. Freshwater mussels play a number of important roles in aquatic ecosystems. As sedentary suspension feeders, mussels remove a variety of materials from the water column, including sediment, organic matter, bacteria, and phytoplankton.

Historically, the Eel River was ranked fourth among Indiana rives in terms of pounds of shells commercially harvested in 1922, and supported a diverse population of 29 species of mussels. However, Henschen (1986-1987) found only 15 species of living mussels in the Eel River and noted that the water was so muddy that it may have impacted his results. According to Henschen most of the mussels were confined to the lower Eel in Cass and Miami Counties. The connection between fish species and mussels is noted in his work, the mussel life cycle includes an obligate parasitic larval stage and requires host fish species for survival. Additionally, he noted that turbidity, primarily from agriculture, and channelization of the upper portion of the Eel River may be adversely affecting not only the mussel populations but also the fish populations. Some mussels are able to utilize a variety of host fishes, but others are restricted to only one or a few fish hosts. Consequently, a change in the composition of fish species present in the Eel River would affect the mussel population (Henschen 1987).

The Eel River fauna is represented by 29 species of mussels (Fisher personal communication). Of these 29 species, 24 species have been documented alive and 5 species have been documented as weather dead shells (which means there was no living organism and the shells were detatched) in the entire Eel River Watershed. Within the Middle Eel River, 13 species have been identified live. There are two federally endangered species, Clubshell and Northern Riffleshell, that have been documented as weather dead shells and one state endangered species, Rabbitsfoot, which has been found alive in the Middle Eel River Watershed with weather dead specimens in the upper portion of the river.

A survey of mussel species was taken once during the grant period at each of the three mainstem monitoring locations and at each of the testing tributaries. A standard one hour roving survey was used to document location of mussel species and mussel beds. Species verification was provided by Brant Fisher, Aquatic Nongame Biologist for the Indiana Department of Natural Resources.

Eighteen riffles were sampled for mussels in 2009. Of the 29 species historically found in the Eel River, 13 live species were identified. A list of mussel species found alive in the Middle Eel River Watershed and a map showing sampling locations can be found in Appendix F-1. Eight live Rabbitsfoot Mussels, a State Endangered species, were identified at 2 locations in 2009, riffle 11 & 12 (Appendix F-2).

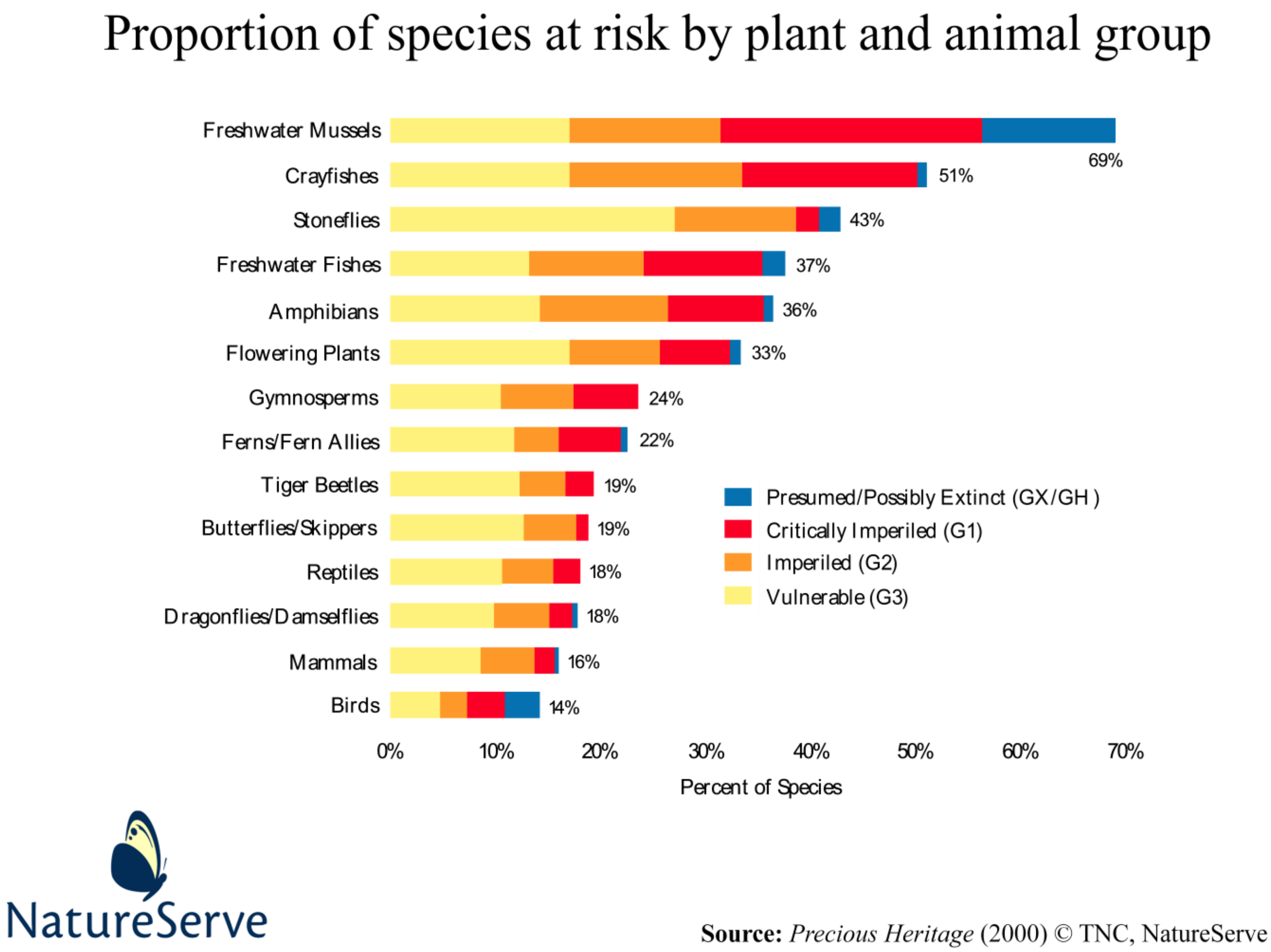

Figure 3-13. US species at risk by animal group. Note freshwater mussels are the highest risk for extinction.

3.5 Qualitative Habitat Evaluation Index (QHEI)

Stream habitat was quantified annually for each of the three mainstem monitoring sites and for each of the six testing tributaries. Habitat scores are based on the Qualitative Habitat Evaluation Index (QHEI) (Rankin 1989). The QHEI provides an assessment tool used widely by stream biologists to quantify the physical parameters that provide habitat for fish and benthic macroinvertebrates. Research has clearly shown positive correlations between QHEI scores and biological-base indices like the Index of Biotic Integrity (IBI) (Rankin 1989). The QHEI is a tool that connects land use to habitat availability or degradation. QHEI scores greater than 60 suggest the stream reach is suitable for warm water habitat.

The QHEI is composed of six metrics which take into account variables such as bottom substrate, channel morphology, riparian cover, and other modifications to the stream or river. A QHEI measurement can have a maximum score of 100. QHEI scores greater than 60 are suitable for warmwater habitat without use impairment. The following is a brief description of the metrics comprising Ohio EPA's QHEI as outlined by Ohio EPA (1989).

- **Substrate** - measures two components - substrate type and substrate quality; takes into account variables like parent material, embeddedness of cobble, gravel and boulders and silt cover. The maximum score is 20

- **Instream Cover** - measures instream cover type and amount. The maximum score is 20

- **Channel Morphology** - includes channel sinuosity, development, stability and channelization; indicates the quality of the stream channel in relation to creation and stability of the macrohabitat. The maximum score is 20

- **Riparian Zone and Bank Erosion** - measures floodplain quality, extent of bank erosion and the width of the riparian zone; serves as indication of the quality of the riparian buffer and floodplain vegetation. The maximum score is 10

- **Pool and Riffle Quality** - component measures include overall diversity of current velocities, pool depth and morphology and riffle-run depth, substrate and substrate quality; serves as indication of the quality of the pool and riffle habitats. The maximum score is a combined 20 (12 for pool, 8 for riffle)

- **Map Gradient** - calculation of elevation drop through sampling area; accounts for varying influence of gradient with respect to stream size. The maximum score is 10

The QHEI was calculated annually for each of the three mainstem gage sites and the six tributaries, results are shown in Figures 3-14 and 3-15.

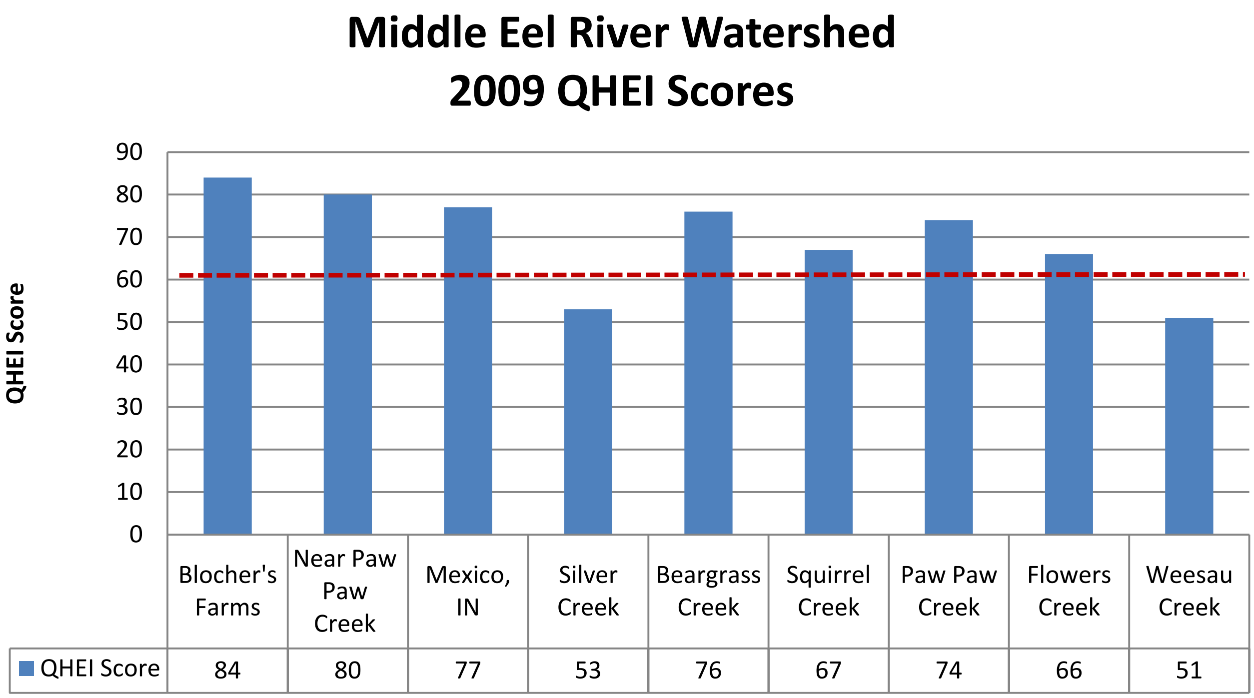

Figure 3-14. Middle Eel River Watershed - QHEI scores for 2009. The red dashed line indicates the acceptable score to support warm water aquatic life without impairment.

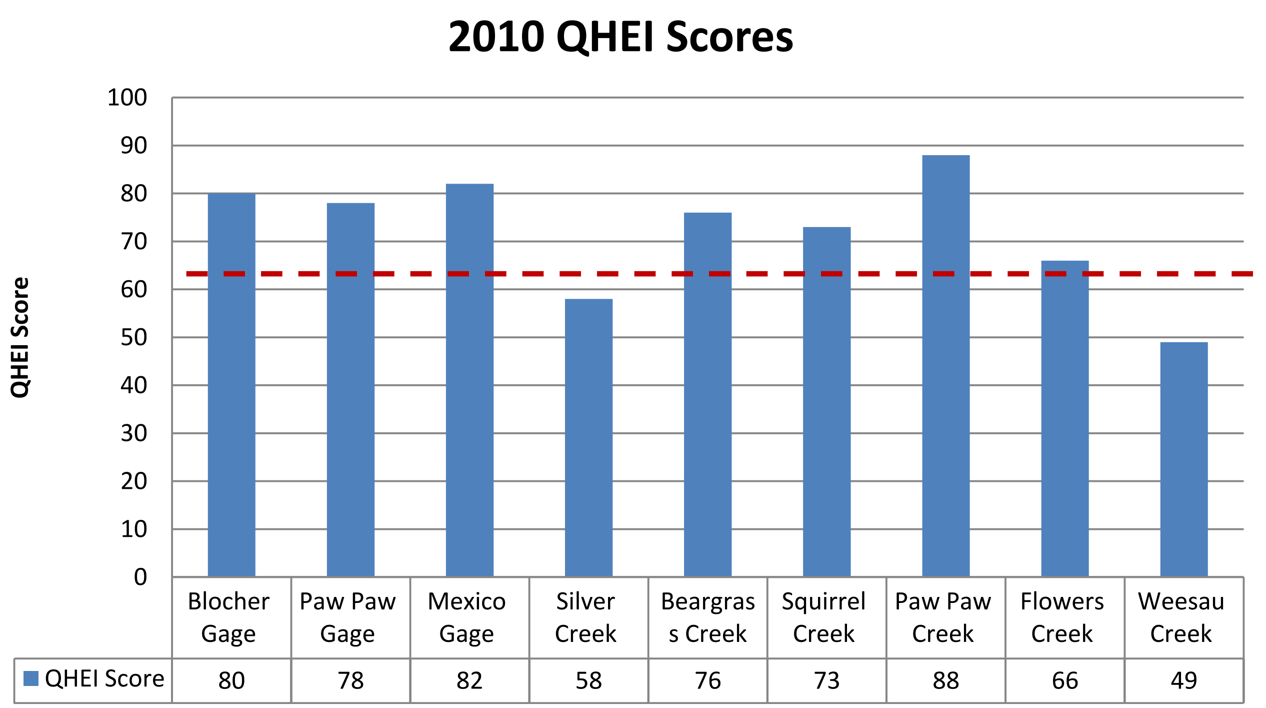

Figure 3-15. Middle Eel River Watershed - QHEI scores for 2010. The red dashed line indicates the acceptable score to support warm water aquatic life without impairment.

The QHEI scores for 2009 and 2010 indicate that there is good habitat in all the tributaries and mainstem testing sites except for Silver Creek and Weesau Creek. The low QHEI scores will be taken into consideration when determining critical areas.

3.6 Fish Assemblages & Index of Biotic Integrity (IBI)

The structure and function of fish communities has been widely used by biologists to provide an indication of stream ecosystem health. The earliest recording of a fish survey on the Eel River was conducted by David Starr Jordan who reported 24 fish species found in the Eel River (Jordan 1888). Jordan commented that the Eel was, "…a rather clear stream." Collecting methods and equipment improvements have allowed a greater accuracy for fish surveys since Jordan's time.

Over the recent past, the most commonly used tool for assessing the fish community is the Index of Biotic Integrity (IBI) (Karr 1981 and Simon 1995). The IBI assesses the fish community based on 12 indices that reflect fish species richness and composition, number and abundance of sensitive species, trophic (feeding) organization and function, reproductive guilds, abundance, and individual fish condition. Scores range from 0 (no fish present) to 60.
A score of 60 represents an excellent fish community as compared to the best reference site for a particular ecoregion. Research from across the United States has clearly demonstrated the effectiveness and reliability of using the IBI as a stream monitoring tool.

The IBI was calculated for each of the three mainstem sites and each of the six tributaries once each year. Fish were identified to species level and scoring will be based on IBI calibration for the Eastern Cornbelt Ecoregion (Simon 1995).

A maximum score of 60 is possible and an IBI score of less than 35 is considered poor or very poor (Sobat, 2009). Table 3-2 below, modified from a table developed by Karr et al. 1986, displays total IBI score, integrity class and attributes to define the fish community characteristics in Indiana streams and rivers.

Table 3-2. IBI Scoring Methodology, integrity class and attributes to define fish community in Indiana streams and rivers.

Total IBI Score	Integrity Class	Attributes
58-60	Excellent	Comparable to "least impacted" conditions, exceptional assemblage of species.
45-52	Good	Decreased species richness (intolerant species in particular), sensitive species present.
35-44	Fair	Intolerant and sensitive species absent, skewed trophic structure.
28-34	Poor	Top carnivores and many expected species absent or rare, omnivores and tolerant species dominant.
12-22	Very Poor	Few species and individuals present, tolerant species dominant, diseased fish frequent.
<12	No Fish	No fish captured during sampling.

Historical IBI scores were compiled by Gammon and are displayed in Table 3-3 below (Gammon 1991).

Table 3-3. Historical IBI Scores in the mainstem and three tributaries, 1972-1990 (Gammon 1990). There has been an improvement in IBI scores for the mainstem from 1972 to 1990

Location	1972 – IBI Score	1982 – IBI Score	1990 – IBI Score
#1 South of Beargrass Creek (RM 37.8) Mainstem	38	42	46
#2 North of Beargrasss Creek (RM 41.4) Mainstem	32	34	36
#3 South of N. Manchester (RM 51.7) Mainstem	42	44	44
Paw Paw Creek Tributary			40
Squirrel Creek Tributary			40
Beargrass Creek Tributary			40

2009 IBI results are listed below in Figure 3-16. The number species and individuals per species collected in 2009 are reported in Appendix E.

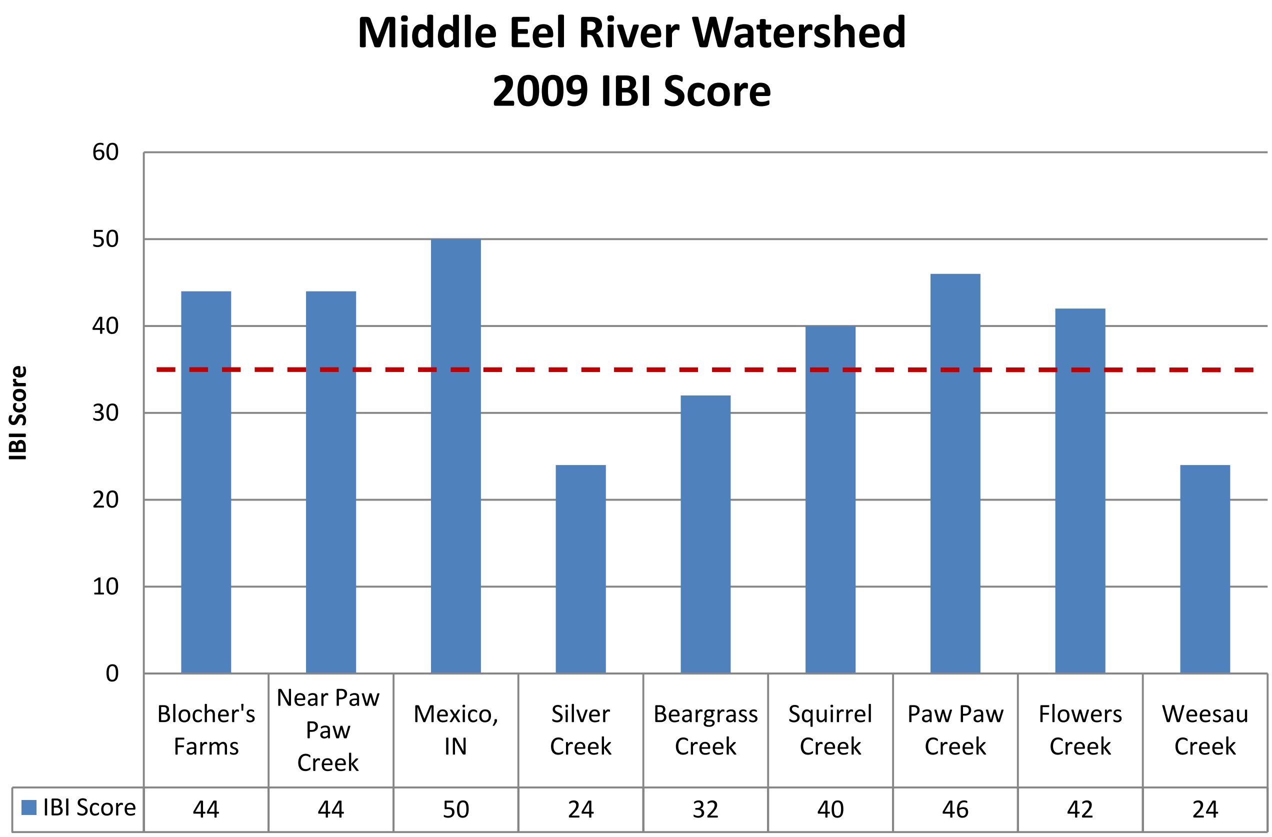

Figure 3-16. Middle Eel River Watershed 2009 IBI scores. The red dashed line indicates the IBI score that represents fair conditions with intolerant and sensitive species absent, skewed trophic structure.

2010 IBI results are listed below in Figure 3-17.

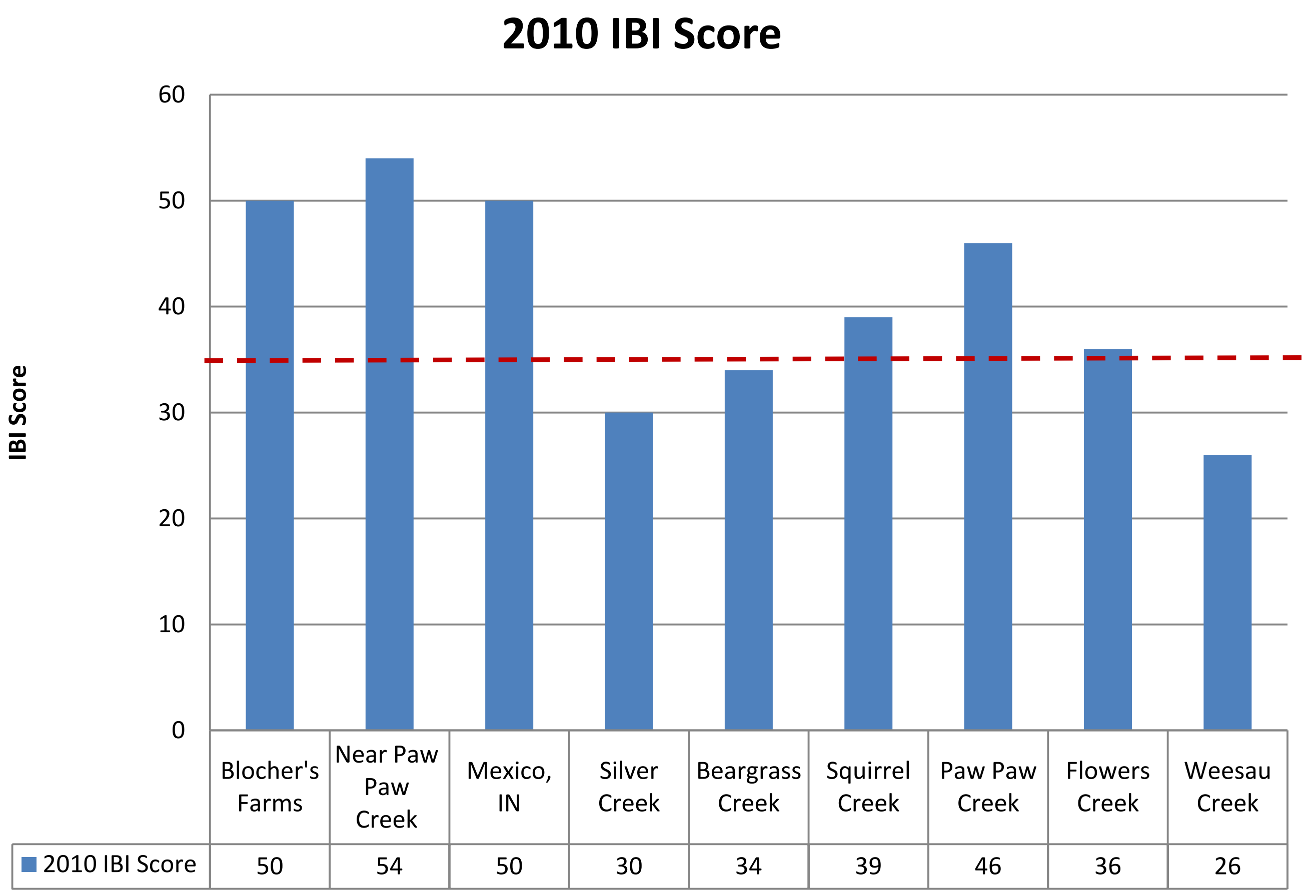

Figure 3-17. Middle Eel River Watershed 2010 IBI scores. The red dashed line indicates the IBI score that represents fair conditions with intolerant and sensitive species absent, skewed trophic structure.

There have been numerous fish kills in the Middle Eel River Watershed reported to IDEM. Figures 3-18 through 3-20 show the number of fish kills reported, number of fish killed, and number of fish kills by watershed that have been reported to IDEM from 2005-2009 (Campbell 2010).

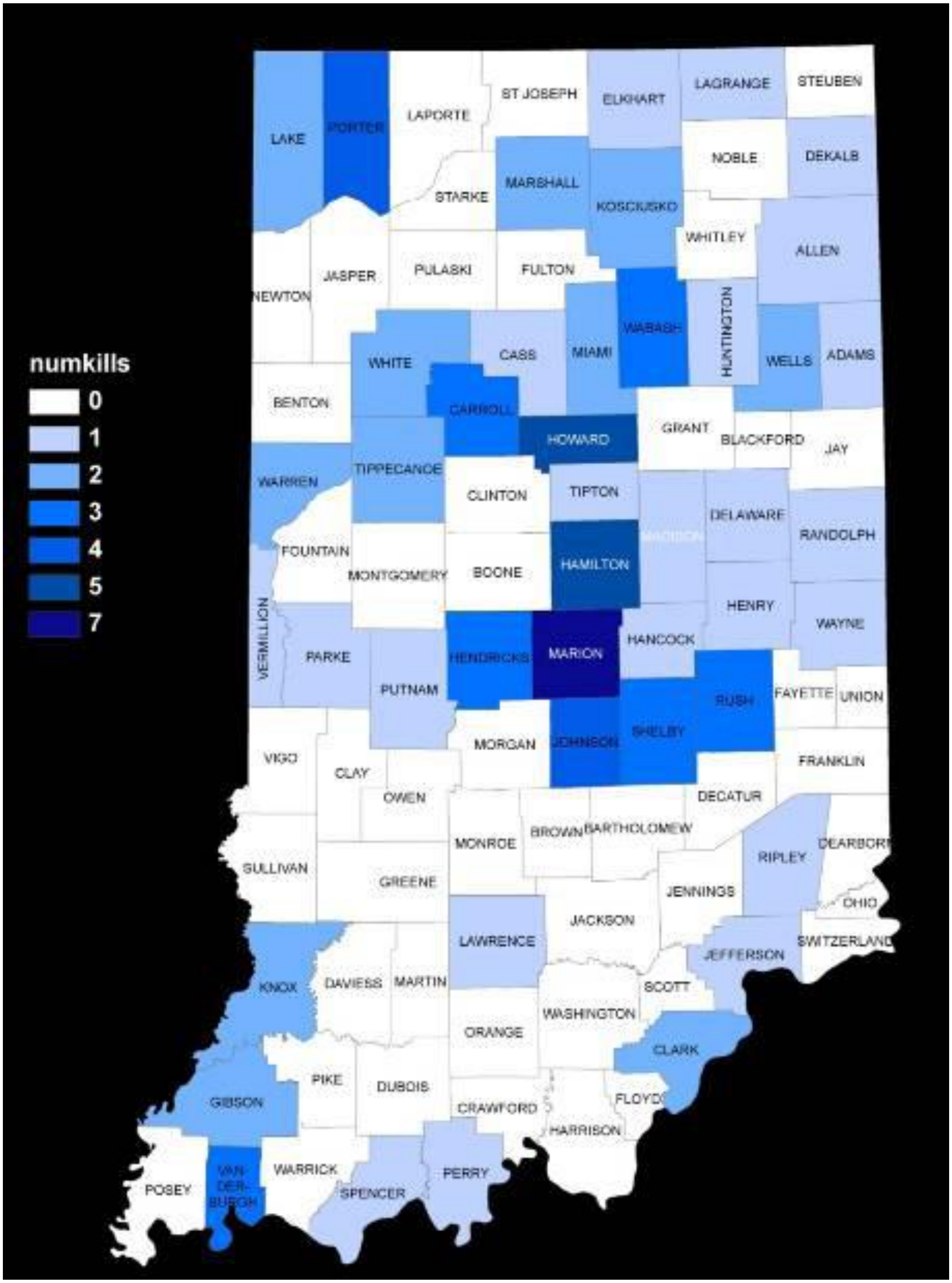

Figure 3-18. Fish kills by Indiana County 2005-2009 (Campbell 2010).

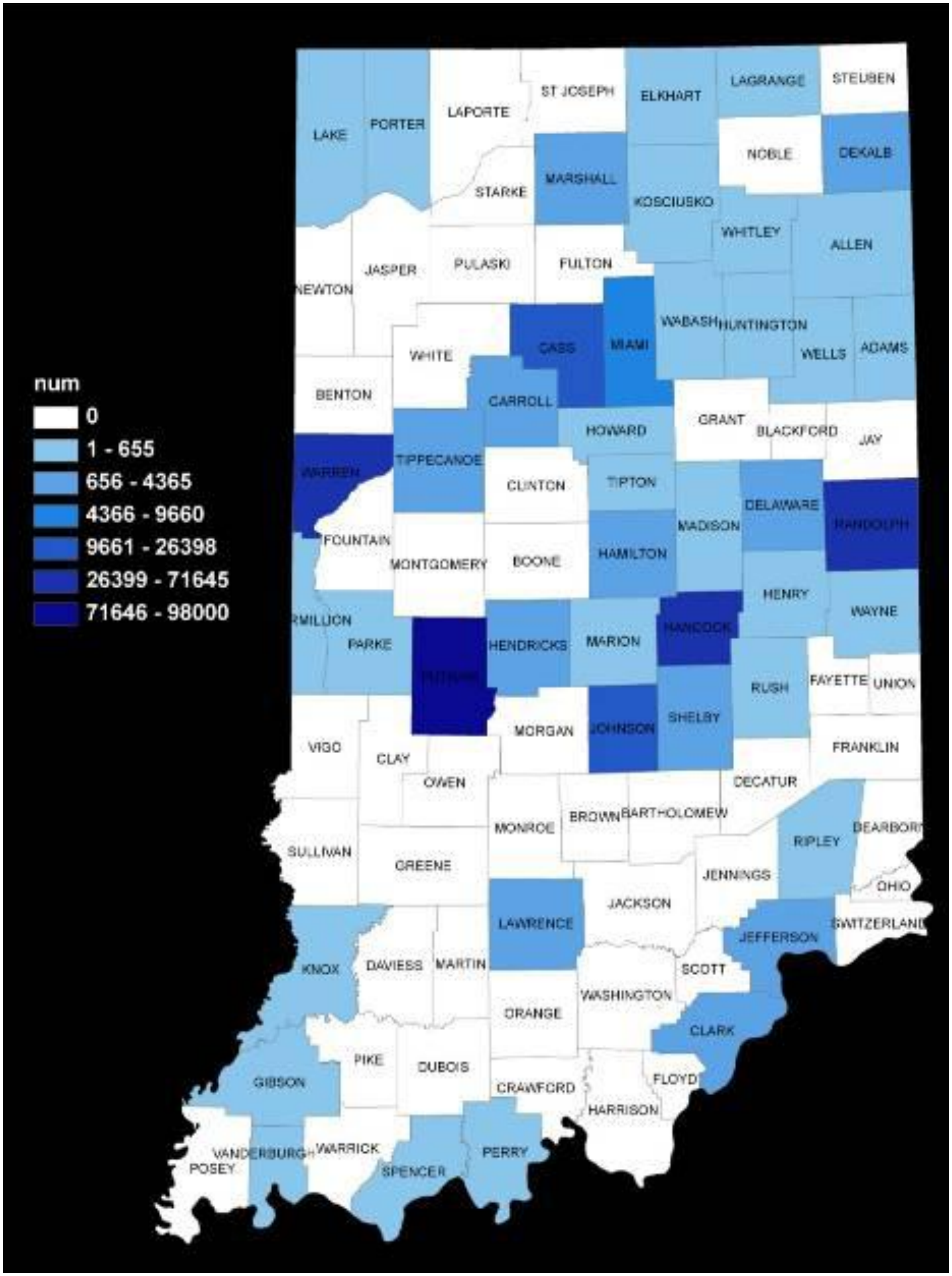

Figure 3-19. Number of fish killed by Indiana County 2005-2009 (Campbell 2010).

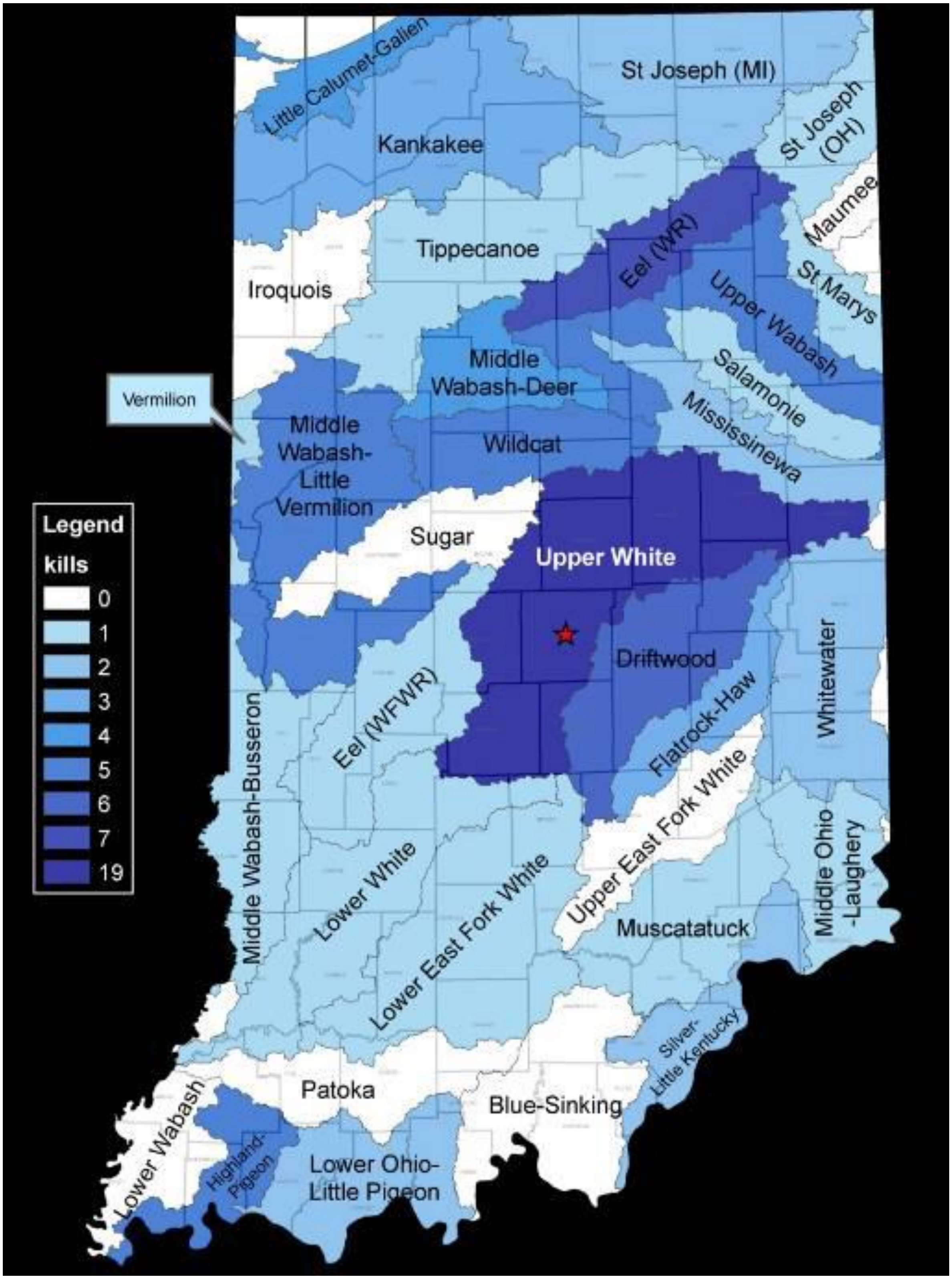

Figure 3-20. Number of fish kills by Indiana Watershed, 2005-2009 (Campbell 2010).

According to Gammon, there has been an improvement in IBI scores from 1972 to 1990. When comparing the 2009 IBI scores to historical data, there has been an increase in IBI scores for Paw Paw Creek, and a decrease in IBI scores for Squirrel Creek and Beargrass Creek. IBI scores for the mainstem are not comparable as they occur historically in different locations than current monitoring.

The 2009 and 2010 IBI scores indicate a fair fish community at all locations except for Silver Creek, Beargrass Creek and Weesau Creek. The low IBI scores will be taken into consideration when identifying critical areas.

A unique situation was discovered in Beargrass Creek where the 2009 QHEI indicated good habitat, but a depressed IBI score indicated a poor fish community. The reasons for this are not yet known and will be taken into consideration when identifying critical areas.

It is also interesting to note that the name of the River, 'Eel', originated from the Miami Indian word, **KE NA PO MO CO**, which means snake fish. The American Eel (a snakelike fish) was very common in the Eel River prior to European settlement when dams began to be built and impeded the catadromous (spend most of their lives in fresh water but migrate to salt water to breed) movement of the species. The last American Eel was discovered in the Eel River in 1986. This species is now considered extirpated from the Middle Eel River.

3.6.1 Smallmouth Bass

The history of smallmouth bass in the Eel River has been well documented over the recent past.

Smallmouth bass is the top predator found in the Eel River and a very popular species of fish for fishermen. To assess the status of smallmouth bass in the Middle Eel River a two kilometer section of the river upstream from the location of each of the three monitoring sites was evaluated. Water temperature, stream velocity, water depth, nest diameter, distance from shore, distance from cover, and latitude/longitude were documented for each nest. Number of eggs present in 10% of the nests located were quantified. The Zippin depletion method of population estimation was used to estimate the smallmouth bass population in three one kilometer sections of the river upstream from the mainstem monitoring sites once in 2009 and once in 2011 (Zippin 1958). Table 3-4 shows the population estimate for 2009, and Figure 3-21 compares population with IBI and QHEI.

Table 3-4. The Zippin three pass depletion population estimation of the smallmouth bass (*Micropterus dolomieui*) at Blocher (40 degrees 59' 31"N and 85 degrees 48' 31"W), Pawpaw (40 degrees 52' 22"N and 85 degrees 58' 42"W), and Mexico (40 degrees 49' 39"N and 86 degrees 6' 50"W) for 2009.

Location	SMB Population
Blocher	45.6
Pawpaw	3
Mexico	10.2

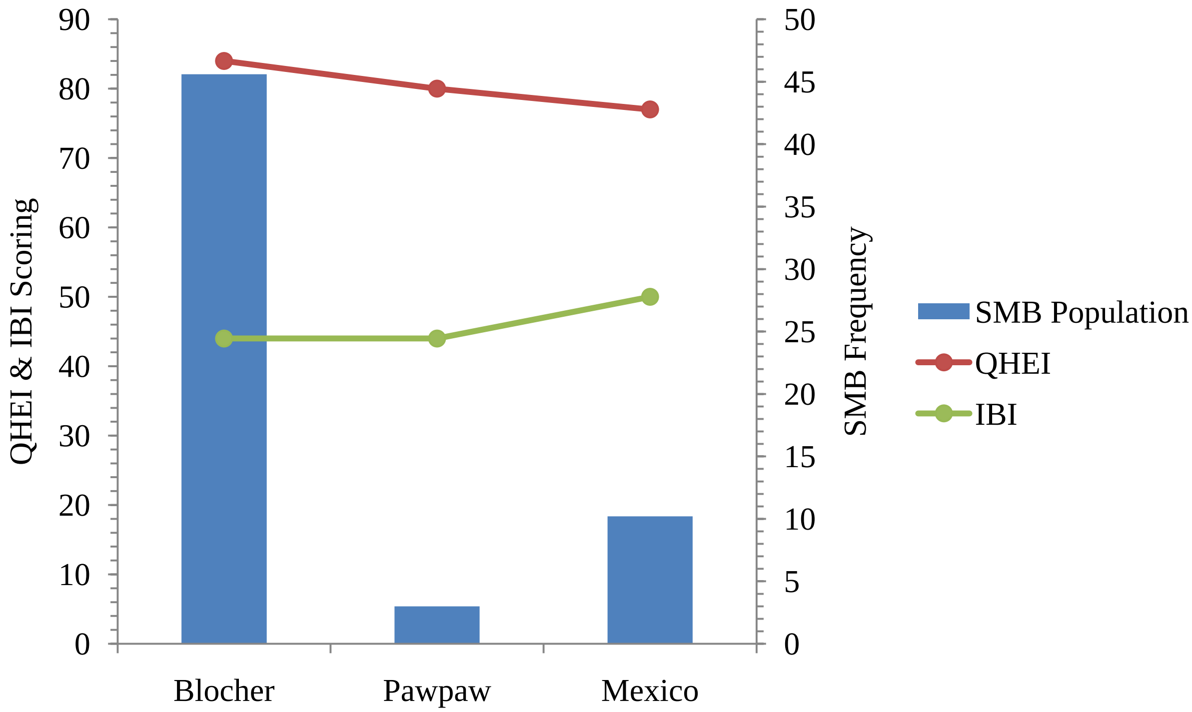

Figure 3-21. The smallmouth bass (*Micropterus dolomieui*) population compared to the QHEI and IBI scores at Blocher (40° 59’ 31”N and 85° 48’ 31”W), Pawpaw (40° 52’ 22”N and 85° 58’ 42”W), and Mexico (40° 49’ 39”N and 86° 6’ 50”W).

The structure of fish populations in streams is dynamic and dependent primarily on available habitat and water quality. While habitat is easily quantifiable and to correlate with fish communities, water quality is more problematic. At the core of this issue is the lack of long-term water quality data sets that are correlated with fish populations. The data presented in this report represents only a one year data set from which it is simply not possible to draw any conclusions at this time. However, historical data (since 2006) suggests that the year class strength and population of smallmouth bass in the Eel River is dynamic. The data indicate that the smallmouth bass population increases after a dry spawning season (May-June) and decreases after a wet spawning season. This trend can be seen after the determination of fish age (from spines) and year class strength compared to stream discharge. During the low flow conditions, there is a significant reduction in total suspended solids (TSS). Research has shown that even low levels of TSS for one or two days may result in a reduction of growth and/or survival of larval and juvenile smallmouth bass. From the fish collected during 2009, there were no fish from the year class of 2008 (a wet year). The large difference in population

Estimations across sites in 2009 are perhaps the result of habitat rather than a difference in water quality. This data set has helped establish a baseline for the next three years and demonstrated the effect of habitat quality. It will be the purpose of this study to continue to examine the population and year class strength of smallmouth bass over the duration of the study in an effort to gain a more clear understanding of the relationship of nonpoint source pollution like TSS and/or habitat.

3.7 Reptiles and Amphibians

This study will not incorporate a reptile and amphibian survey, and there is currently no published data regarding reptiles and amphibians of the Middle Eel River Watershed.

3.8 Water Chemistry

While it is well known that water chemistry is important in any water quality monitoring initiative, most often selected parameters are measured as grab samples and are taken daily, weekly, or at somewhat random intervals without knowledge of stream discharge. These data give only a small glimpse into the dynamic nature of streams and may not provide a clear representation of organismal exposure or loadings of any of the constituents being analyzed.

This study included three sample sites on the mainstem of the river that were equipped with Isco automatic water samplers that allowed water samples to be taken from the river throughout storm events and six times daily during baseflow conditions (Figure 3-1). The sampler was connected to a pressure transducer and a datalogger that continually recorded stream discharge and water temperature. Three samples were analyzed daily at baseflow conditions with all six samples analyzed daily during storm events.

The first year of sampling began May 28, 2009 and continued through July 13, 2009. Monitoring began May 7 and continued through July29 in 2010. Monitoring will occur May 1, through June 31 for the remainder of the grant period (2011 and 2012). These dates coincided well with planting times of agricultural crops and with the spawning activity of most fish and are considered the ‘field season’.

Parameters that were measured on-site daily included: water and air temperature (^{o}C), pH, conductivity (microsiemens/cm), dissolved oxygen (DO) (mg/L), and stream dishcharge (cubic feet per second). Total phosphorus (mg/L), nitrate (mg/L), total suspended solids (TSS) and turbidity (mg/L and NTU) were performed at the Manchester College laboratory as outlined in the Quality Assurance Project Plan for the Middle Eel River Watershed Initiative (Appendix D).

3.8.1 *Escherichia coli* (*E. coli*)

Escherichia coli (*E. coli*) quantification is routinely used in stream water quality monitoring as an indicator of "safe conditions". Diseases such as Typhoid, Giardia, Cryptosporidium, and Shigella may be transmitted by the ingestion of water contaminated with fecal matter. *E. coli* is associated with the intestinal tract of warm blooded animals and serves as an indicator of fecal pollution in the water. *E. coli* is used as an indicator because it is easier to identify, and less expensive, than monitoring for all the possible types of pathogens (an infectious agent, or more commonly germ, is a biological agent that causes disease to its host) that cause a specific disease.

In Indiana all waters are designated for full body contact recreational use between April and October with a water quality standard for *E.coli* of 125 colony forming units (CFU)/100 mL in a single sample, or as a geometric mean based on not less than 5 samples equally spaced over 30 days, or 235 CFU/100mL in any one sample in a 30 day period.

E. coli were strategically sampled and measured at each of the testing locations every two weeks, and for selected rain events from the three primary monitoring sites on the mainstem of the river.

The collected data indicates that *E. coli* was the main cause of impairment for the Middle Eel River and the testing tributaries. Table 3-5 shows water quality standards for *E. coli* were **not** met one time for Silver Creek and Squirrel Creek. Standards were met once during 2009 in Flowers Creek, and twice in Beargrass Creek. Paw Paw Creek, with 5 samples meeting the state standard, had the most water samples that met the standard.

The gage stations on the mainstem did not meet the geometric mean standard of 125 CFU/100mL for *E. coli*, but were overall lower than the results of the testing tributaries, possibly due to a dilution factor. The gage stations rarely met the single sample standards of 235CFU/100mL in any one sample in a 30 day period. The yellow highlighting in Table 3-5 indicates the samples that failed to meet state water quality standards.

The testing tributaries very rarely met the state standards for geometric mean or single samples which demonstrates the magnitude of the problem within the watershed.

E. coli may come from the feces of any warm blooded animal including livestock, wildlife, domestic animals and humans. It may also come from the application of manure as fertilizer, failing or improperly sited septic systems, and overflow from a combined sewer overflow system. The contamination may occur directly, such as livestock having access to a stream, or indirectly from failed septic systems, in any case it is the main cause of the Eel River and its tributaries being listed on the

IDEM 303(d) List. It is not uncommon to see cattle grazing in a field with direct access to the streams in the watershed (Figure 3-22). Confined animal feeding operations are common in the watershed and are discussed in more detail in Section 2, pages 83-91.

Figure 3-22. Middle Eel River Watershed, cattle in stream. Photograph by Terri Michaelis.

Table 3-5. Middle Eel River Watershed, *E. coli* single sample results for all sites sampled in 2009 from the most upstream gage and convergence with the Eel River to the most downstream. Highlighted results do not meet Indiana standards for full body contact of 235 CFU/100mL in any one sample in a 30 day period.

Date	Blocher Gage	Paw Paw Gage	Mexico Gage	Silver Creek	Beargrass Creek	Squirrel Creek	Paw Paw Creek	Flowers Creek	Weesau Creek
28-May-09		480	97						
01-Jun-09				5,500	8,600	4,400	640	1,500	1,150
08-Jun-09	160	160	3	750	230	955	220	1,030	270
10-Jun-09	26,000	9,000	470	7,300	46,000	38,000	260	160,000	21,000
13-Jun-09	8,550	6,200	8,000	5,700	2,700	43,000	9,450	5,600	41,000
20-Jun-09	450	280	290	17,000	903	1,460	430	643	790
24-Jun-09	133	270	240	610	920	620	260	1,080	520
12-Jul-09	2,100	800	250	7,100	2,800	8,700	380	2,800	590
15-Jul-09	240	100	260	500	400	450	200	1,233	200
31-Jul-09	300	760	550	640	240	1,600	240	340	790
18-Aug-09				175,000	22,000	82,000	5,200	>80,000	108,000
29-Aug-09	1,600	780	230	5,800	260	6,300	160	1,066	233
16-Sept-09	160	47	23	740	280	420	150	6,400	340
08-Oct-09	130	26	23	400	200	370	170	3,486	80
02-Nov-09	350	620	670	390	320	980	330	190	490

Due to the high E coli. results in Flowers Creek in 2009, the site was split and sampling began upstream in Wilson Rhodes Ditch above its confluence with Flowers Creek to try to determine the origin of the *E. coli* (Figure 3-23). Table 3-6 displays dates and results for Wilson Rhodes Ditch above its confluence with Flowers Creek. Highlighted results do not meet Indiana standards of 235 CFU/100mL in any one sample in a 30 day period. The source was never identified for these extremely high E. coli counts, however, the results for 2010 were more in-line with the other testing tributaries.

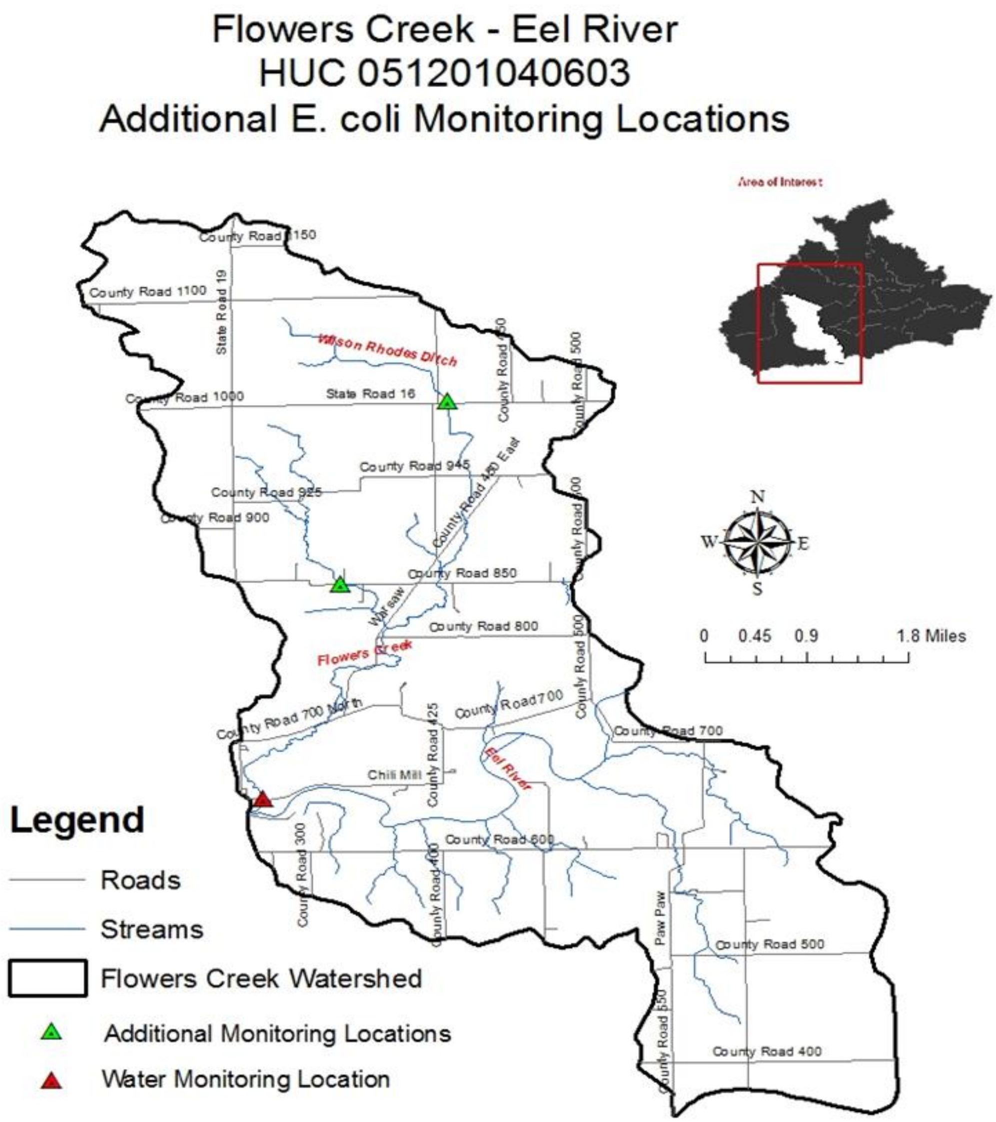

Figure 3-23. Additional E. coli monitoring locations on Wilson Rhodes Ditch.

Table 3-6. *E coli* results from May to July 2009, Wilson Rhodes Ditch above confluence with Flowers Creek. Highlighted results do not meet Indiana standards for full body contact of 235 CFU/100mL in any one sample in a 30 day period.

Date	Wilson Rhodes Ditch
29-Aug-09	1,100
16-Sept-09	1,700
08-Oct-09	187,000
02-Nov-09	290

The Indiana standards for geometric mean of *E. coli* is 125 CFU/100mL from 5 equally spaced samples over a 30 day period. The geometric mean for each of the testing locations for 2009 and 2010 is shown in Tables 3-7 through Table 3-10. None of the testing locations met the state standards for geometric means of *E. coli* and this will be considered when determining critical areas.

Table 3-7. Middle Eel River Watershed testing tributaries E. coli geometric mean (2009 Field Season) and subwatershed acreage, May 28-July 13, 2009. Highlighted results do not meet Indiana standards for full body contact of 125 CFU/100mL in any one sample in a 30 day period.

Testing Tributaries E. coli Geometric Mean 2009 Field Season (FS) (Indiana Standard Geometric Mean of 125cfu/100mL)						
	Silver Creek	Squirrel Creek	Weesau Creek	Flowers Creek	Paw Paw Creek	Beargrass Creek
Geometric Mean	2,211	2,705	1,345	2,056	451	1365
Acreage	20,163	15,192	14,853	13,581	35,118	14,793

Table 3-8. Middle Eel River Watershed gage stations E. coli geometric mean (2009 Field Season) and subwatershed acreage, May 28-July 13, 2009.

Mainstem Gage Stations E. coli Geometric Mean 2009 June (Indiana Standard Geometric Mean of 125cfu/100mL)			
	Blocher Gage	Paw Paw Gage	Mexico Gage
Geometric Mean	585	613	236
Acreage	92,442	120,179.5	49,192.8

Table 3-9. Middle Eel River Watershed testing tributaries E. coli geometric mean (June 2010 and Field Season) and subwatershed acreage, May 7-July 29, 2010. Highlighted results do not meet Indiana standards for full body contact of geometric mean of 125 CFU/100mL in any one sample in a 30 day period.

Testing Tributaries E. coli Geometric Mean 2010 June and Field Season (FS) (Indiana Standard Geometric Mean of 125cfu/100mL)						
	Silver Creek	Squirrel Creek	Weesau Creek	Flowers Creek	Paw Paw Creek	Beargrass Creek
Geometric Mean	June 2,419 FS – 3,360	June 5,897 FS – 3,360	June 1,942 FS – 1,468	June 1,853 FS – 1,433	June 1,067 FS – 1,429	June 849 FS – 674
Acreage	20,163	15,192	14,853	13,581	35,118	14,793

Table 3-10. Middle Eel River Watershed gage stations E. coli geometric mean (June 2010 and Field Season) and subwatershed acreage, May 7-July 29, 2010. Highlighted results do not meet Indiana standards for full body contact of geometric mean of 125 CFU/100mL in any one sample in a 30 day period.

Mainstem Gage Stations E. coli Geometric Mean 2010 June and Field Season (FS)(Indiana Standard Geometric Mean of 125cfu/100mL)			
	Blocher Gage	Paw Paw Gage	Mexico Gage
Geometric Mean	June – 1,897 FS – 1,272	June – 2,285 FS – 1,543	June – 1,866 FS – 1,280
Acreage	92,442	120,179.5	49,192.8

3.8.2 Total Suspended Solids (TSS)

Total suspended solids (TSS) is a measure of the amount of particulate solids that are in solution. This is an indicator of nonpoint source pollution problems associated with various land use practices, particularly agricultural land use. The TSS measurement is expressed in (mg/L).

Soil pollution, or suspended sediment, is by volume the largest pollutant in Indiana waters (Sweeten 2002), and the USEPA identifies suspended sediment as the single most widespread pollutant in the Nation's rivers and streams. It is the largest nonpoint source pollutant by volume within the Middle Eel River Watershed.

There are no water quality standards set by the state of Indiana for TSS, however concentrations between 25.0-80.0 mg/L have been shown to reduce fish concentrations (IDEM - Water Quality Targets nd.). Suspended sediment is known to smother spawning habitat, increase water temperature, clog fish gills and limit the ability of young larval sight feeding fish to find their prey which results in a depressed fish community, particularly of non-tolerant species such as Smallmouth Bass. TSS of no more than 25 mg/L is the target for the Initiative.

Middle Eel River Watershed 2009 and 2010 TSS results are displayed in Tables 3-11 through 3-14 below. TSS in the water originates from many sources, but a large portion of sediment entering streams comes from stream bank erosion due to lack of riparian buffers, livestock access to streams, and wind and water erosion on agricultural land. Since 89% of land use within the watershed is agricultural, the largest contributor to TSS is likely cropland erosion, lack of riparian buffers and livestock in the streams.

Table 3-11. Middle Eel River Watershed testing tributaries TSS mg/L median, maximum, minimum and subwatershed acreage, May 28-July 13, 2009.

Testing Tributaries TSS mg/L 2009 Field Season (No Indiana Standard, 25 mg/L known to reduce fish concentrations)						
	Silver Creek	Squirrel Creek	Weesau Creek	Flowers Creek	Paw Paw Creek	Beargrass Creek
Median	17	14	4	3	4	8
Mean	34	28	28	33	7	39
Maximum	256	148	224	244	40	290
Minimum	0	4	0	0	0	1
Acreage	20,163	15,192	14,853	13,581	35,118	14,793

Table 3-12. Middle Eel River Watershed mainstem gage stations TSS mg/L median, maximum, minimum and subwatershed acreage, May 28-July 13, 2009.

Mainstem Gage Stations TSS mg/L 2009 Field Season (No Indiana Standard, 25 mg/L known to reduce fish concentrations)			
	Blocher Gage	Paw Paw Gage	Mexico Gage
Median	16	16	16
Mean	59	41	34
Maximum	807	352	188
Minimum	0	1	1
Acreage	92,442	120,179.5	49,192.8

Table 3-13. Middle Eel River Watershed testing tributaries TSS mg/L median, maximum, minimum and subwatershed acreage, May 7-July 29, 2010.

Testing Tributaries TSS mg/L 2010 Field Season (No Indiana Standard, 25 mg/L known to reduce fish concentrations)						
	Silver Creek	Squirrel Creek	Weesau Creek	Flowers Creek	Paw Paw Creek	Beargrass Creek
Median	38	22	19	8	14	18
Mean	50	42	58	31	51	51
Maximum	180	219	354	167	404	594
Minimum	4	0	1	0	0	0
Acreage	20,163	15,192	14,853	13,581	35,118	14,793

Table 3-14. Middle Eel River Watershed mainstem gage stations TSS mg/L median, maximum, minimum and subwatershed acreage, May 7-July 29, 2010.

Mainstem Gage Stations TSS mg/L 2010 Field Season (No Indiana Standard, 25 mg/L known to reduce fish concentrations)			
	Blocher Gage	Paw Paw Gage	Mexico Gage
Median	62	58	57
Mean	117	103	94
Maximum	960	1473	923
Minimum	0	1	0
Acreage	92,442	120,179.5	49,192.8

3.8.3 Dissolved Oxygen

Dissolved oxygen (DO) is the amount of oxygen dissolved in water, measured in milligrams per liter (mg/L). DO enters the water by diffusion from the atmosphere and as a byproduct of photosynthesis of algae and plants. DO in the water is critical to the survival of various aquatic life in streams, and is essential for fish respiration. The ability of water to hold oxygen in solution is inversely proportional to the temperature of the water. For example, the cooler the water temperature, the more dissolved oxygen it can hold.

The Indiana standards for dissolved oxygen are 4.0 mg/L to 12 mg/L. All of the testing locations within the Middle Eel River met the state standards. Water can become low in DO due to the respiration of aquatic organisms, such as fish and algae, and also during bacterial decomposition of plant and animal matter. In other words, when an algae bloom has occurred and is dying off and decomposing, this process uses up DO in the water, resulting in a lack of oxygen for other organisms. These algae bloom may be caused from an abundance of nutrients available to the algae. It is the low DO that has caused the 'Dead Zone' or 'Hypoxic Zone' in the Gulf of Mexico. Middle Eel River Watershed 2010 Dissolved Oxygen results are displayed in Tables 3-15 and 3-16 below.

Table 3-15. Middle Eel River Watershed testing tributaries dissolved oxygen mg/L median, maximum, minimum and subwatershed acreage, May 11-July 29, 2010.

Testing Tributaries Dissolved Oxygen mg/L 2010 Field Season (Indiana Standard 4.0-12 mg/L)						
	Silver Creek	Squirrel Creek	Weesau Creek	Flowers Creek	Paw Paw Creek	Beargrass Creek
Median	7.3	7.9	8.7	7.7	7.8	8.0
Mean	7.4	8.0	8.7	7.7	8.0	8.1
Maximum	8.5	9.4	9.9	9.2	9.6	9.6
Minimum	6.7	7.2	8.1	6.7	6.8	6.5
Acreage	20,163	15,192	14,853	13,581	35,118	14,793

Table 3-16. Middle Eel River Watershed mainstem gage stations dissolved oxygen mg/L median, maximum, minimum and subwatershed acreage, May 11-July 29, 2010.

Mainstem Gage Stations Dissolved Oxygen mg/L 2010 Field Season (Indiana Standard 4.0-12 mg/L)			
	Blocher Gage	Paw Paw Gage	Mexico Gage
Median	7.4	7.7	7.3
Mean	7.7	8.2	7.7
Maximum	16.6	20.0	18.8
Minimum	5.9	6.6	3.7
Acreage	92,442	120,179.5	49,192.8

3.8.4 Nitrate

Nutrient pollution, especially from nitrogen and phosphorus, has consistently ranked as one of the top causes of degradation in some U.S. waters for more than a decade. Excess nitrogen and phosphorus lead to significant water quality problems including harmful algal blooms, hypoxia and declines in wildlife and wildlife habitat.

Over-fertilization of lawns or agricultural fields, failing septic systems, and livestock having direct access to streams, result in nitrates entering our rivers and streams, which can cause excessive plant growth. These plants can clog canals and streams, increasing flooding and decreasing recreational use, and when the plants die and decay, they can use up too much oxygen which results in an impaired biotic community, or low DO. Nitrate moves easily with water and may enter the streams through field tile runoff and is mobile in the soil profile and can easily leach and contaminant aquifers.

Livestock and humans can be harmed from drinking water high in nitrates, however, since the Eel River is not a drinking water source for humans within the watershed, however, further downstream the city of Logansport draws approximately half of their water from the Eel River. This demonstrates the need to expand the Watershed Initiative to include the southern reaches of the Eel River. The main concern within the Middle Eel Watershed is for livestock health and algae growth. In addition to the local concern for nitrate (and phosphorus) levels, the combined effect of all the Mississippi River Basins' watersheds are contributing to the hypoxic zone in the Gulf of Mexico.

Nitrate (NO^-_3) is a dissolved form of nitrogen that is commonly found in rapidly moving streams and is a form of nitrogen that plants can easily use. There is no state standard for nitrate levels except for waters designated as a drinking water source. The dividing line between mesotrophic and eutrophic streams (Dodd et al. 1998) is 1.5 mg/L. The US EPA recommendation for nitrate is a maximum of 0.633 mg/L, which is the target for this Intitiative. Middle Eel River Watershed 2009 and 2010 Nitrate results are displayed in Tables 3-17 through 3-20 below.

Table 3-17. Middle Eel River Watershed testing tributaries nitrate mg/L median, maximum, minimum and subwatershed acreage, May 28-July 13, 2009.

Testing Tributaries Nitrate mg/L 2009 Field Season (USEPA recommended standard is maximum of 0.633 mg/L)						
	Silver Creek	Squirrel Creek	Weesau Creek	Flowers Creek	Paw Paw Creek	Beargrass Creek
Median	0.900	0.500	1.200	1.800	2.400	2.400
Mean	0.888	1.120	1.633	2.440	2.527	2.813
Maximum	2.000	6.700	4.900	6.300	6.500	8.900
Minimum	0.300	0	0.100	0.700	0	0.400
Acreage	20,163	15,192	14,853	13,581	35,118	14,793

Table 3-18. Middle Eel River Watershed mainstem gage stations nitrate mg/L median, maximum, minimum and subwatershed acreage, May 28-July 13, 2009.

Mainstem Gage Stations Nitrate mg/L 2009 Field Season (USEPA recommended standard is maximum of 0.633 mg/L)			
	Blocher Gage	Paw Paw Gage	Mexico Gage
Median	0.700	0.800	0.950
Mean	1.124	1.114	1.226
Maximum	6.700	4.700	5.500
Minimum	0	0	0
Acreage	92,442	120,179.5	49,192.8

Table 3-19. Middle Eel River Watershed testing tributaries nitrate mg/L median, maximum, minimum and subwatershed acreage, May 7-July 29, 2010.

Testing Tributaries Nitrate mg/L 2010 Field Season (USEPA recommended standard is maximum of 0.633 mg/L)						
	Silver Creek	Squirrel Creek	Weesau Creek	Flowers Creek	Paw Paw Creek	Beargrass Creek
Median	2.550	3.900	5.000	6.600	8.450	9.100
Mean	2.681	4.278	4.975	6.897	8.063	8.897
Maximum	6.100	11.700	10.600	12.600	14.700	15.900
Minimum	1.500	0.700	1.000	0.200	2.300	2.000
Acreage	20,163	15,192	14,853	13,581	35,118	14,793

Table 3-20. Middle Eel River Watershed mainstem gage stations nitrate mg/L median, maximum, minimum and subwatershed acreage, May 7-July 29, 2010.

Mainstem Gage Stations Nitrate mg/L 2010 Field Season (USEPA recommended standard is maximum of 0.633 mg/L)			
	Blocher Gage	Paw Paw Gage	Mexico Gage
Median	3.300	3.800	3.900
Mean	3.899	3.932	4.024
Maximum	33.800	7.900	7.300
Minimum	0.700	0.300	0.400
Acreage	92,442	120,179.5	49,192.8

3.8.5 Ammonia

Ammonia (NH_3) is highly toxic to aquatic organisms and at low levels acts as a strong irritant, especially to the gills. Prolonged exposure to low levels can lead to skin and gill hyperplasia (an abnormal increase in the number of cells) resulting in a condition in which the secondary gill lamellae (gill filaments) swell and thicken, restricting the water flow over the gill filaments. This can result in respiratory problems and stress on aquatic organisms.

The Indiana standard for total ammonia is between 0.0 and 0.21 mg/L depending upon pH and temperature.

The primary agricultural sources of ammonia are spills of ammonia rich fertilizers and livestock waste from barnyards, feedlots, pastures and rangeland. Other sources are household use of ammonia containing cleaning products and improper disposal of them, and faulty septic systems.

Middle Eel River Watershed 2009 and 2010 Ammonia results are displayed in Tables 3-19 through 3-22 below.

Table 3-21. Middle Eel River Watershed testing tributaries ammonia mg/L median, maximum, minimum and subwatershed acreage, May 28-July 13, 2009.

Testing Tributaries Ammonia mg/L 2009 Field Season (Indiana State Standard is maximum of 0.0 to 0.21 mg/L, varies with temperature)						
	Silver Creek	Squirrel Creek	Weesau Creek	Flowers Creek	Paw Paw Creek	Beargrass Creek
Median	0.080	0.076	0.053	0.060	0.050	0.070
Mean	0.096	0.105	0.117	0.108	0.960	0.099
Maximum	0.232	0.352	0.745	0.577	0.519	0.341
Minimum	0.044	0.045	0.009	0.027	0.011	0.013
Acreage	20,163	15,192	14,853	13,581	35,118	14,793

Table 3-22. Middle Eel River Watershed mainstem gage stations ammonia mg/L median, maximum, minimum and subwatershed acreage, May 28-July 13, 2009.

Mainstem Gage Stations Ammonia mg/L 2009 Field Season (Indiana State Standard is maximum of 0.0 to 0.21 mg/L, varies with temperature)			
	Blocher Gage	Paw Paw Gage	Mexico Gage
Median	0.052	0.043	0.040
Mean	0.113	0.072	0.057
Maximum	0.857	0.417	0.463
Minimum	0.006	0	0.004
Acreage	92,442	120,179.5	49,192.8

Table 3-23. Middle Eel River Watershed testing tributaries ammonia mg/L median, maximum, minimum and subwatershed acreage, May 7-July 29, 2010.

Testing Tributaries Ammonia mg/L 2010 Field Season (Indiana State Standard is maximum of 0.0 to 0.21 mg/L, varies with temperature)						
	Silver Creek	Squirrel Creek	Weesau Creek	Flowers Creek	Paw Paw Creek	Beargrass Creek
Median	0.071	0.0735	0.065	0.068	0.069	0.067
Mean	0.081	0.129	0.110	0.103	0.102	0.129
Maximum	0.271	0.611	0.384	0.434	0.395	0.814
Minimum	0.043	0.035	0.020	0.024	0.021	0.021
Acreage	20,163	15,192	14,853	13,581	35,118	14,793

Table 3-24. Middle Eel River Watershed mainstem gage stations ammonia mg/L median, maximum, minimum and subwatershed acreage, May 7-July 29, 2010.

Mainstem Gage Stations Ammonia mg/L 2010 Field Season (Indiana State Standard is maximum of 0.0 to 0.21 mg/L, varies with temperature)			
	Blocher Gage	Paw Paw Gage	Mexico Gage
Median	0.075	0.062	0.056
Mean	0.125	0.095	0.085
Maximum	1.090	1.040	0.714
Minimum	0.019	0.017	0.014
Acreage	92,442	120,179.5	49,192.8

3.8.6 Total Phosphorus

As stated earlier, nutrient pollution, especially from nitrogen and phosphorus, has consistently ranked as one of the top causes of degradation in some U.S. waters for more than a decade. Excess nitrogen and phosphorus lead to significant water quality problems including harmful algal blooms, hypoxia and declines in wildlife and wildlife habitat.

Phosphorus is often the limiting factor in aquatic ecosystems, and excessive phosphorus may result in algal blooms. Phosphorus binds with soil particles, particularly clay particles, consequently it moves with the soil during run off events. The contribution of phosphorus and nitrates from the agricultural areas of the Mississippi Drainage Basin are a major contributing factor to the Hypoxic Zone in the Gulf of Mexico.

Phosphorus is an essential plant nutrient found in fertilizer and human and animal wastes. Phosphorus can travel attached to particles of soil or manure eroded by water into a stream, or in runoff water from agricultural fields into streams. Conventional tillage, application of fertilizers and/or manure, failing septic systems, feedlot runoff, and combined sewer overflow are potential sources of high phosphorus levels in the watershed.

The recommended US EPA standard for total phosphorus in Indiana waters is a maximum of 0.076 mg/L and is the target for the Initiative. Middle Eel River Watershed 2009 and 2010 Total Phosphorus results are displayed in Tables 3-23 through 3-26 below.

Table 3-25. Middle Eel River Watershed testing tributaries total phosphorus mg/L median, maximum, minimum and subwatershed acreage, May 28-July 13, 2009.

Testing Tributaries Total Phosphorus mg/L 2009 Field Season (USEPA recommended standard is maximum of 0.076 mg/L)						
	Silver Creek	Squirrel Creek	Weesau Creek	Flowers Creek	Paw Paw Creek	Beargrass Creek
Median	0.365	0.416	0.342	0.418	0.310	0.479
Mean	0.484	0.446	0.495	0.602	0.433	0.698
Maximum	2.190	1.100	2.270	2.930	0.762	2.300
Minimum	0.202	0.175	0.224	0.047	0.176	0.302
Acreage	20,163	15,192	14,853	13,581	35,118	14,793

Table 3-26. Middle Eel River Watershed mainstem gage stations total phosphorus mg/L median, maximum, minimum and subwatershed acreage, May 28-July 13, 2009.

Mainstem Gage Stations Total Phosphorus mg/L 2009 Field Season (USEPA recommended standard is maximum of 0.076 mg/L)			
	Blocher Gage	Paw Paw Gage	Mexico Gage
Median	0.449	0.400	0.348
Mean	0.671	0.564	0.460
Maximum	4.59	2.250	1.370
Minimum	0.041	0.103	0
Acreage	92,442	120,179.5	49,192.8

Table 3-27. Middle Eel River Watershed testing tributaries total phosphorus mg/L median, maximum, minimum and subwatershed acreage, May 7-July 29, 2010.

Testing Tributaries Total Phosphorus mg/L 2010 Field Season (USEPA recommended standard is maximum of 0.076 mg/L)						
	Silver Creek	Squirrel Creek	Weesau Creek	Flowers Creek	Paw Paw Creek	Beargrass Creek
Median	0.522	0.448	0.425	0.545	0.535	0.676
Mean	0.590	0.651	0.700	0.753	0.697	0.944
Maximum	1.660	1.9300	2.900	2.210	3.760	3.150
Minimum	0.226	0.1510	0.109	0.194	0.106	0.138
Acreage	20,163	15,192	14,853	13,581	35,118	14,793

Table 3-28. Middle Eel River Watershed mainstem gage stations total phosphorus mg/L median, maximum, minimum and subwatershed acreage, May 7-July 29, 2010.

Mainstem Gage Stations Total Phosphorus mg/L 2010 Field Season (USEPA recommended standard is maximum of 0.076 mg/L)			
	Blocher Gage	Paw Paw Gage	Mexico Gage
Median	0.766	0.779	0.714
Mean	1.019	0.961	0.897
Maximum	6.250	6.560	4.860
Minimum	0.258	0.253	0.133
Acreage	92,442	120,179.5	49,192.8

3.8.7 Conductivity

Conductivity is useful as a general measure of stream water quality. Each stream tends to have a relatively constant range of conductivity, that, once established, can be used as a baseline for comparison with regular conductivity measurements. Significant changes in conductivity could then be an indicator that a discharge or some other source of pollution has entered a stream.

Discharges to streams can change the conductivity depending on their make-up. A failing sewage system would raise the conductivity because of the presence of chloride, phosphate, and nitrate; an oil spill would lower the conductivity. The conductivity of rivers in the United States generally ranges from 50 to 1500 microsiemens per centimeter (µs/cm). Studies of inland fresh waters indicate that streams supporting good mixed fisheries have a range between 150 and 500 µs/cm. Conductivity outside this range could indicate that the water is not suitable for certain species of fish or macroinvertebrates (an animal without a skeletal structure).

Middle Eel River Watershed 2010 Conductivity results are displayed in Tables 3-29 and 3-30 below. There is no state standard or recommended standard for conductivity since it varies by water body.

Table 3-29. Middle Eel River Watershed testing tributaries Conductivity µs/cm median, mean, maximum, minimum and subwatershed acreage, May 11-July 29, 2010.

Testing Tributaries Conductivity µs/cm 2010 Field Season (No State or Federal Standards)						
	Silver Creek	Squirrel Creek	Weesau Creek	Flowers Creek	Paw Paw Creek	Beargrass Creek
Median	292	314	297	314	293	303
Mean	357	400	341	381	323	356
Maximum	628	640	606	651	633	649
Minimum	249	253	210	32	148	148
Acreage	20,163	15,192	14,853	13,581	35,118	14,793

Table 3-30. Middle Eel River Watershed mainstem Gage Stations Conductivity µs/cm median, mean, maximum, minimum and subwatershed acreage, May 11-July 29, 2010.

Mainstem Gage Stations Conductivity µs/cm 2010 Field Season (No State or Federal Standards)			
	Blocher Gage	Paw Paw Gage	Mexico Gage
Median	312	303	312
Mean	333	346	333
Maximum	612	607	612
Minimum	139	130	139
Acreage	92,442	120,179.5	49,192.8

3.8.8 Water Temperature

Temperature is important because it governs the kinds of aquatic life that can live in a stream and it can determine the form, solubility, and toxicity of a broad range of aqueous compounds (compounds dissolved in water). Fish, insects, zooplankton, phytoplankton, and other aquatic species all have a preferred temperature range. If temperatures get too far above or below this preferred range, the number of individuals of the species decreases until finally they are unable to survive and results in an impaired biotic community.

Temperature also is important because it influences water chemistry. The rate of chemical reactions generally increases at higher temperatures, which in turn affects biological activity. An important example of the effects of temperature on water chemistry is its impact on oxygen. Warm water holds less oxygen than cool water, so it may be "saturated" with oxygen but still not contain enough for survival of aquatic life. Some compounds are also more toxic to aquatic life at higher temperatures. Removal of shade-providing vegetation in the riparian corridor may cause an increase in water temperatures.

Indiana water quality standards state that water temperature at no time during the month of May exceed 25.0 °C and during the months of June and July water temperature shall not exceed 30.5 °C. Middle Eel River Watershed 2010 Water Temperature results are displayed in Table 3-31 and 3-32 below. The water temperature at all testing locations fell within the state standards.

Table 3-31. Middle Eel River Watershed testing tributaries Water Temperature °C median, mean, maximum, minimum and subwatershed acreage, May 11-July 29, 2010.

Testing Tributaries Water Temperature °C 2010 Field Season (Indiana State Standards - no time during the month of May exceed 25.0 °C and during the months of June and July water temperature shall not exceed 30.5 °C.)						
	Silver Creek	Squirrel Creek	Weesau Creek	Flowers Creek	Paw Paw Creek	Beargrass Creek
Median	19.9	19.1	18.8	17.5	20.0	19.2
Mean	19.4	18.8	18.7	17.0	19.5	19.1
Maximum	22.9	22.9	28.8	19.8	24.5	24.5
Minimum	12.6	12.1	13.0	11.7	12.0	11.2
Acreage	20,163	15,192	14,853	13,581	35,118	14,793

Table 3-32. Middle Eel River Watershed mainstem Gage Stations Water Temperature °C median, mean, maximum, minimum and subwatershed acreage, May 11-July 29, 2010.

Mainstem Gage Stations Water Temperature °C 2010 Field Season (Indiana State Standards - no time during the month of May exceed 25.0 °C and during the months of June and July water temperature shall not exceed 30.5 °C.)			
	Blocher Gage	Paw Paw Gage	Mexico Gage
Median	21.0	21.2	22.1
Mean	20.4	20.4	22.3
Maximum	25.3	25.2	25.1
Minimum	12.8	11.7	19.9
Acreage	92,442	120,179.5	49,192.8

3.8.9 Water Quality Entering the Middle Eel River Watershed

It is important to note that water quality entering the middle section of the Eel River contains high levels of ammonia, total phosphorus, total suspended solids and *E. coli*. For these parameters of concern, the water quality actually improves as it moves through the middle section of the Eel River. In order to attain state or federal standards, it is imperative that the water entering the middle section of the Eel River be improved. This could be accomplished developing watershed management plans and implementing best management practices in the upper reaches of the Eel River

3.9 Fish Consumption Advisory

While testing of fish tissue for mercury and PCBs is not part of this study, it is important to note that this is a serious concern within the watershed. Fish is generally a good source of protein, minerals, and vitamins and can be very healthy for you. However, some fish may absorb contaminants from the water, and soils, where they live and the food that they eat. The major contaminants of concern are polychlorinated biphenyls (PCBs), mercury and pesticides. Older fish and predatory fish (fish that eat other fish) contain larger amounts of pollutants.

Mercury is a naturally occurring metal that does not break down in the environment, but continually cycles between land, water and air. Mercury is released in large amount from coal fired power plants and also from burning household and industrial wastes, and leaching from landfills. Consuming large amounts of mercury may harm an adult's nervous system and is especially toxic to unborn children. Mercury is bound to fish muscles and there is no method of cooking or cleaning the fish that will reduce the mercury.

PCBs are synthetic oils that were once widely used in electrical transformers and capacitors, and break down very slowly in the environment. PCBs and pesticides tend to be stored in the fat of fish, particularly in fatty fish such as carp and catfish. Cooking and cleaning fish to remove fat will lower the amount of PCBs consumed. Most of the fat is located near the skin of the fish. PCBs may cause developmental problems in children and may cause cancer in humans.

A Fish Consumption Advisory is issued by the Indiana Dept. of Health in cooperation with IDEM and IDNR for Indiana waterways and can be found online at http://www.in.gov/isdh/23650.htm. The 2010 Fish Consumption Advisory published by the Indiana Dept. of Health stated that the Eel River is in Advisory Group 3 and states that, "Consumption of fish from the Eel River should be limited to no more than one meal per month (Group 3) by the general population and NO CONSUMPTION by the at-risk population." The only exceptions to this advisory is if the general population is consuming a bluegill larger than six inches, or a carp larger than 24 inches, then it should be treated as an Advisory Group 4 and only one meal every two months should be consumed.